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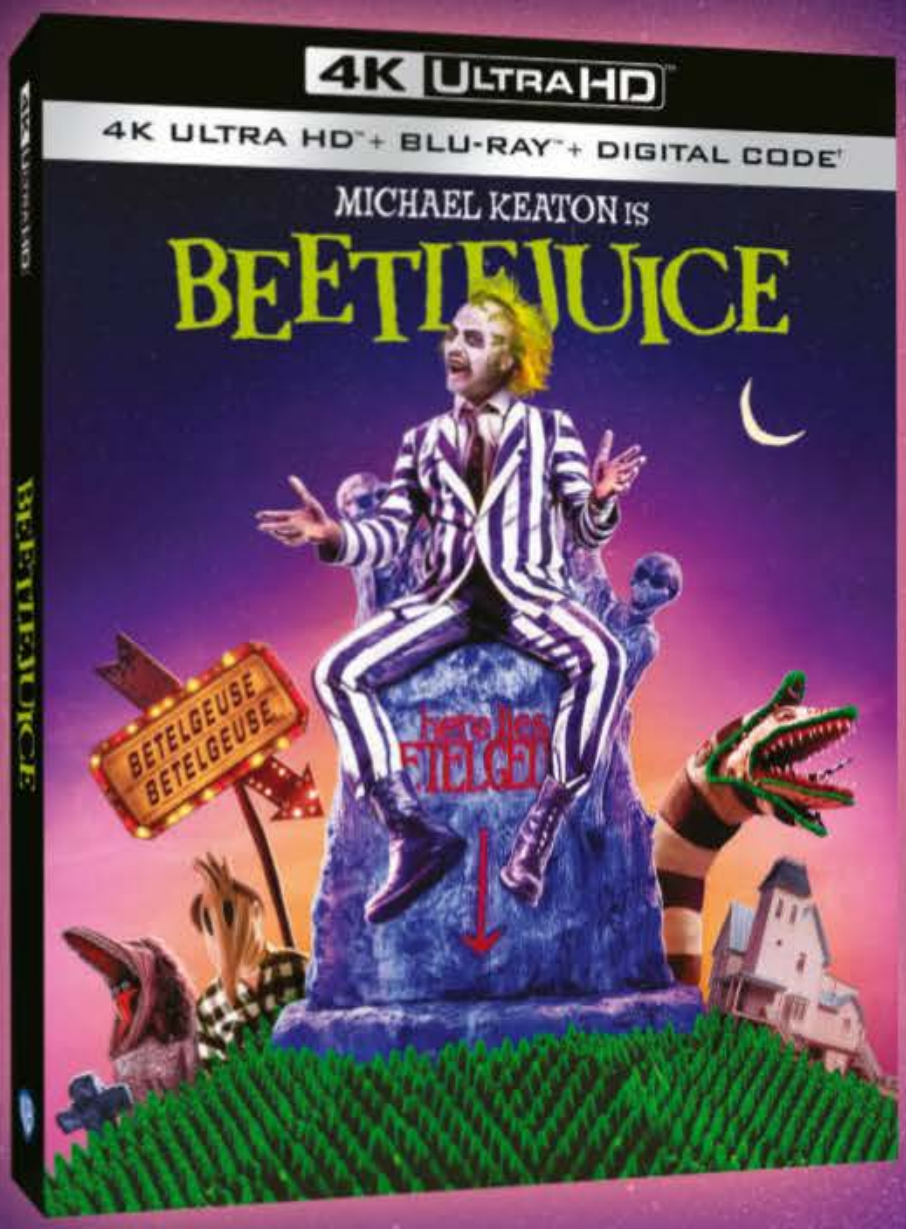

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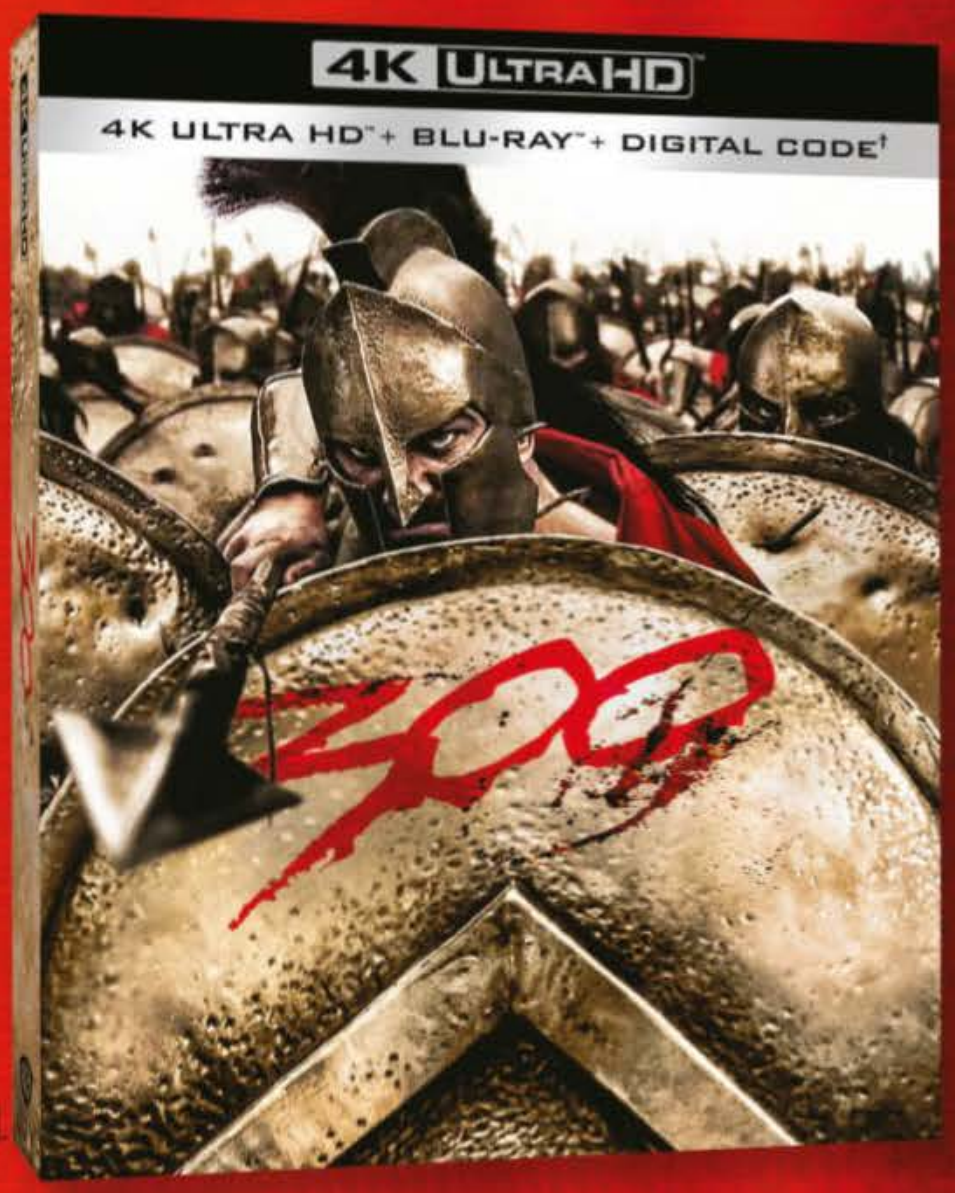

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Zak Storey

OF COOLANT AND KEYBOARDS

IT'S HAPPENING! It's finally happening—we're back in the office. Sort of. Well, at least one Monday every other week, as a team, anyway. I mean, it's not "normal" normal, but it'll do for now, while the world is still in turmoil.

In fact, this is the first time I've ever physically sat in the *Maximum PC* editor's chair, and boy, does it feel good. You can say what you like about working from home, but nothing quite beats the social aspects and camaraderie you have with a well-meshed team when you meet up in person, as opposed to over voice chat. But enough of my ramblings—mag updates abound, and I finally have some good news.

So, this issue is known as issue 183 for internal purposes. Think of that number like an Intel architectural code-name—we still operate on volumes, but for the purpose of budgets, we need an arbitrary number. We've no idea where that number comes from—it's certainly not the number of issues that have ever been printed—but what we do know is that it goes up by an increment of one each issue. And what I can tell you is that as of issue 185 (our Holiday 2020 edition), we're returning to our pre-lockdown budget and page count. At last, we'll finally be back up to 100 pages of crisp, fresh content each and every issue.

I just want to say to all of you who are still here: Genuinely, thank you for sticking by us. It means the world to myself and the team, and it also means we can continue to bring you the very best content we can, and hopefully amp up the online stuff, as intended, too, once we've got the remaining 40% of our budget back. And on top of our return to a full lip-smacking budget, we've also moved across to a new subscription platform in the form of Magazinesdirect.com. All the prices should remain the same as before, but if you're having trouble with your subscription, are looking to renew, or sort out missing issues, I've been assured that the customer support team there is far superior to the one we were using previously. To cover the changeover, I've been personally forwarding on all of your problems directly to our subscriptions team internally as well.

So, what have we got in this issue? Well, there's a fantastic full 10-page case study of a somewhat scary new coolant we've been testing, an introduction to the world of custom mechanical keyboards from Dave (who, I've been told, has spent no less than $19,000 on keyboards over the years), and a full in-depth guide to the latest and greatest distros Linux has to offer. Combine all that with a quick look at our case-test builds for chassis reviews going forward, and a bevy of hardware, columns, tutorials, and more, and I hope there's something for everyone in the latest issue.

Stay safe out there, and I'll see you on the other side.

Zak Storey is Maximum PC's *editor and long-time staff member. He's been building PCs since he was 10, and is more than capable of butting heads with the biggest names in tech.*

↘ submit your questions to: comments@maximumpc.com

THE NEWS

Tiger Lake Lands

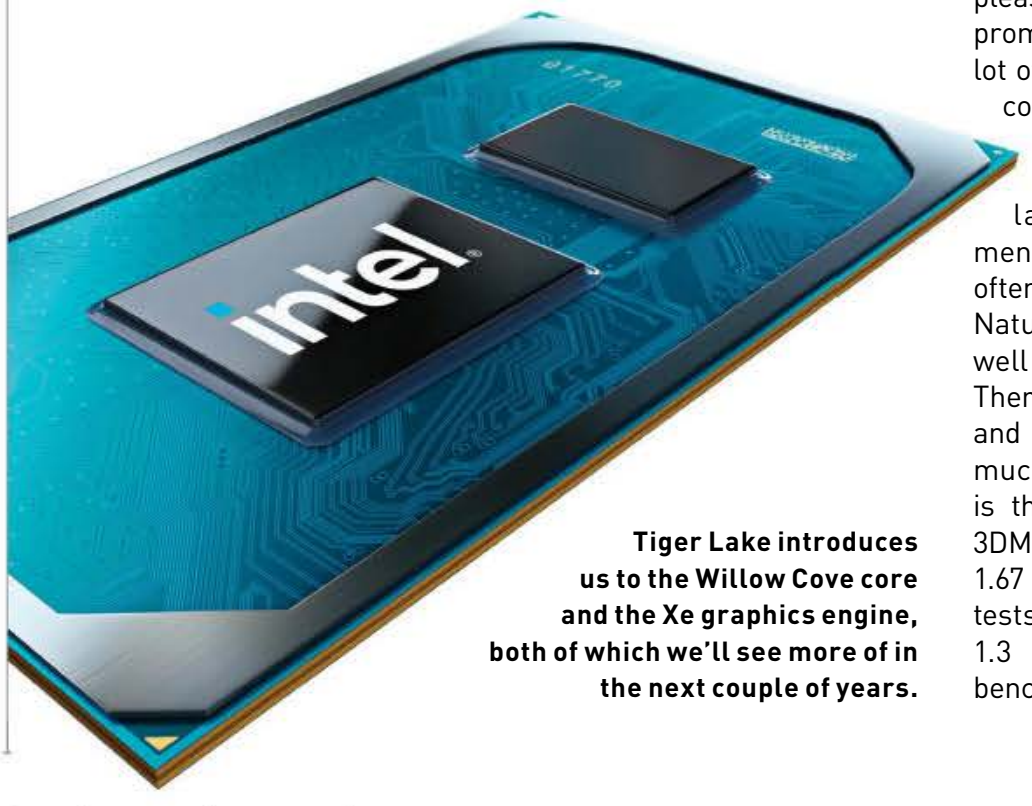
A whole new family of low-power chips

IT'S BEEN a while since Intel had something properly new and shiny to boast about. Now it does: Tiger Lake has finally arrived. It's a family of 11th-gen mobile processors using the Willow Cove microarchitecture coupled to the new Xe graphics engine. It replaces Ice Lake, which used Sunny Cove cores (the first proper new microarchitecture design from Intel since 2015's Skylake).

Before we get too excited, Intel has started at the bottom—the first wave of Tiger Lake processors is all the U series, aimed at low-power mobile devices of up to 28W. Tiger Lake uses a 10nm SuperFin process, essentially a new name for the 10nm+ process. Let's hope Intel continues to stop adding "+" to the end of things for good: 14nm++++ just looks ridiculous.

The basic technical specifications make good reading. Along with higher clock speeds, we have integrated PCIe 4.0 and Thunderbolt 4 support, and LPDDR4 or LPDDR5 memory. We also have hardware video decoding, up to four displays, support for 8K, ultra-wide 12-bit color, and prodigious video and image-processing support. There are two packages: A larger UP3 for devices up to 28W, and a smaller UP4 package (formally Y series) for devices under 15W.

The initial chips are branded from Core i3 to i7. The top model is the Core i7-1185G7, with four cores and eight threads, a base clock of 3.0GHz, and a maximum boost to 4.8GHz. This is 700MHz more than the best of the previous-gen U-series, and 600MHz faster than the best of AMD's Renoir APUs.



Tiger Lake introduces us to the Willow Cove core and the Xe graphics engine, both of which we'll see more of in the next couple of years.

At the bottom of the range is the Core i3-1110G4, a two-core chip with a base clock of 1.8GHz, and a maximum boost of 3.9GHz. The first batch of releases consists of five 28W UP3 chips and four 15W UP4 versions, each sporting i3, i5, and i7 names.

This is the first outing of Intel's Xe graphics engine, a hugely important part of the company's plans. Tiger Lake has two main configurations. The G7 chips have 96 or 80 execution units, while the smaller G4s have 48. This low-power version of Xe is twice as fast as the previous Gen-11 engine. We will be seeing much more of Xe over the next couple of years, as it is destined to appear right across Intel's silicon, including powering discrete graphics cards.

Intel certainly appears to be pleased with Tiger Lake, the promotional material making a lot of comparisons with AMD's contender in this segment, the Ryzen Renoir 4000 series. Actually Intel's launch presentations mentioned AMD chips more often than Intel's own products. Naturally Tiger Lake scores well in these comparisons. There was a raft of bar charts and slides showing just how much better the i7-1185G7 is than a 4800U, including a 3DMark Fire Stike score that is 1.67 times faster. Productivity tests showed gains of around 1.3 times. The AI-powered benchmarks were particularly revealing; Tiger Lake has some real capability here with its DL Boost (Deep Learning). Yes, these are cherry-picked tests by Intel to show the chip in the best light, but the fact that a four-core Tiger Lake can give an eight-core Renoir real trouble is encouraging.

How much? We've no idea yet, nor does it matter. Tiger Lake is aimed squarely at OEMs. There will be around 50 new Tiger Lake machines ready for the holidays, and over 150 are planned in all. Along with Tiger Lake, Intel has outlined the 2nd generation of Project Athena laptops, now using the Intel Evo branding. The Tiger Lake H series, aimed at beefier mobiles, is due early next year. These are pitched against AMD's Cezanne chip, which should also arrive early next year. AMD has managed to break into the lucrative mobile market after years in the cold, and now powers some big models. Tiger Lake switches the focus back to Intel.

Tiger Lake is good news for Intel after some lean times, but also a little frustrating. All this nice new tech is only available in low-power mobile devices. When can we have this technology in a desktop chip? Rumor has it that Willow Cove will be "back-ported" to 14nm with Rocket Lake next year. This should bring a useful 15 to 20 percent bump in IPC.

One more bit of news: Intel has a new logo, and it does look more serious now. **–CL**

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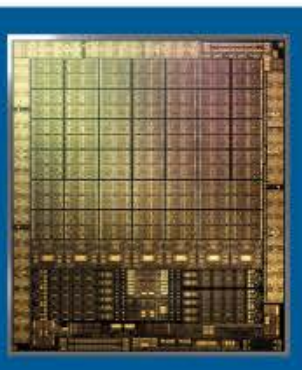
AMPERE LANDS

2nd-gen RTX cards aim high



NVIDIA HAS LAUNCHED AMPERE, its new 8nm GPU chip architecture, and the performance bump over Turing is a healthy one. Nvidia boasts of nearly doubling just about every metric. There are three initial cards. The RTX 3070 costs $499, has 5,888 CUDA cores and 8GB of memory. The mid-range RTX 3080 is $699 with 8,704 cores and 10GB. The monster is the RTX 3090 at $1,499. It has 10,496 cores, and 24GB of GDDR6, This is near Titan-level pricing for a GeForce-branded card.

Turing was launched two years ago and brought a raft of new technologies, but was expensive and had issues, so the RTX didn't sell in huge numbers.

Ampere appears to have fixed this. The pricing is more realistic, and DLSS now works effectively and doesn't hit the frame rates so hard, making it feasible to render at 1080p and scale to 4K faster than you can render 4K directly. The RT engine performs twice the operations per clock. It seems many of the things we were promised with Turing 20-series are coming with Ampere 30-series. **–CL**

OCULUS INTEGRATED

YOU MUST HAVE A FACEBOOK ACCOUNT

WHEN FACEBOOK BOUGHT OCULUS in 2014, one of Oculus's founders, Palmer Luckey, said you won't need to log onto Facebook to use your headset, and it became a semi-autonomous brand of Facebook. In 2018 it became a division of Facebook Technologies. Now Facebook is to integrate all user account functions. So, you will need to sign up to Facebook to use Oculus Rift. There will be no more new Oculus accounts. Existing users can merge their Oculus and Facebook accounts, which will become obligatory at the end of 2022.

The move hasn't been well received by users and developers, but where it will make a big difference is in overseas markets. Oculus has had to stop selling in Germany because the coupling of products and services violates European law on data protection. So if you hate Facebook enough to avoid it, you've just lost access to Oculus headsets **–CL**.

Tech Triumphs and Tragedies

A monthly snapshot of what's good and bad in tech

TRIUMPHS

VERY BIG APPLE
Apple has doubled its value in two years to $2 trillion. It's the world's most valuable company.

HALF OF GAMERS ARE ON PC
There are 3.1 billion active gamers in the world, and the PC/console split is near even, with 48% opting for the PC.

ARTIFICIAL PHOTOSYNTHESIS
A university team has made a material than can convert sunlight into formic acid to power fuel cells.

TRAGEDIES

INVENTORS ARE HUMAN
After two patent applications on behalf of an AI system, the U.S. Patent Office has ruled that it only grant patents to "natural persons."

DATA
Premom, a top pregnancy app, has been caught selling users' data to Chinese companies, although thankfully not the medical data.

HALO INFINITE DELAYED
It looks like the new Xbox won't launch with its *Halo* title: The game has been delayed until next year.

APPLE VS. EPIC

Fortnite ousted from Apple as pair fight over fees

IN AUGUST EPIC announced a new payment method in *Fortnite* that bypassed Apple and Google's usual 30 percent commission. You got more V-Bucks for your real bucks. Apple were not having this, and promptly removed *Fortnite* from its App Store, while Google also removed it from Android's Google Play Store. Epic responded with an anti-trust lawsuit, claiming Apple's App Store was effectively a monopoly. Apple then proposed blocking Epic's access to developer accounts. That would have hurt Epic's ability to maintain the Unreal engine. Fortunately the judge issued a temporary restraining order to stop Apple, commenting that it had "chosen to act severely."

Apple's wealth makes it a tough target for legal challenges. Epic came to court well prepared, but Apple appears to be quite happy to let the process last for months. The situation with Google is less strained—the main target of Epic's ire is Apple. You can still play *Fortnite* on your iPhone, but you won't get new downloads, so no new seasons until this is sorted.

Nobody appears to be hinting at a compromise yet. Let us hope there is a quick and decisive legal ruling, although if past cases show us anything it is that companies generally spend a lot of money on lawyers to argue in public, before sorting things out in private. **–CL**

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THE LIST

THE MOST UNUSUAL LOGOS IN TECH

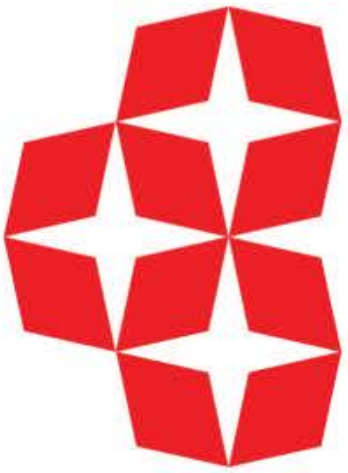
8 MICROSOFT 1980 Something weird clearly happened at Microsoft as it transitioned out of the 70s, hence this funky logo that looks heavily inspired by metal bands.

7 SONY 1955 Sony has sported essentially the same classic logo since 1957, but before that came this odd, stretched-out, rather lopsided iteration.

6 ACER 1987 What's going on here? Acer kept this logo for over a decade, despite it weirdly swapping between lowercase and uppercase. A lowercase e followed by an uppercase R, really?

5 CORSAIR 2015 Corsair had a pretty solid base design here, but including the questionable "Do Your Thing" slogan in branding material was an odd call in our opinion...

4 SAMSUNG 1979 This was Samsung's logo for close to two decades, and yet it's unrecognizable today. 1992 brought the logo we know now, a huge visual change for the tech giant.



3 WINDOWS MOVIE MAKER 2000 Microsoft has really improved the visual appeal of Windows. This is a perfect example of what they had to change: Ugly, overdesigned logos.

2 GOOGLE STADIA 2019 We've been told that the Stadia logo is meant to be an S, but it just looks like an odd zigzag to us. A confused logo for a confused product, perhaps?

1 LOGITECH LOGI 2015 Dropping the technology aspect to simply become "Logi" was a big move for Logitech, and didn't really pan out, since it quietly returned to the original brand name.

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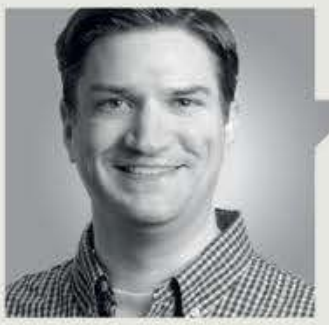
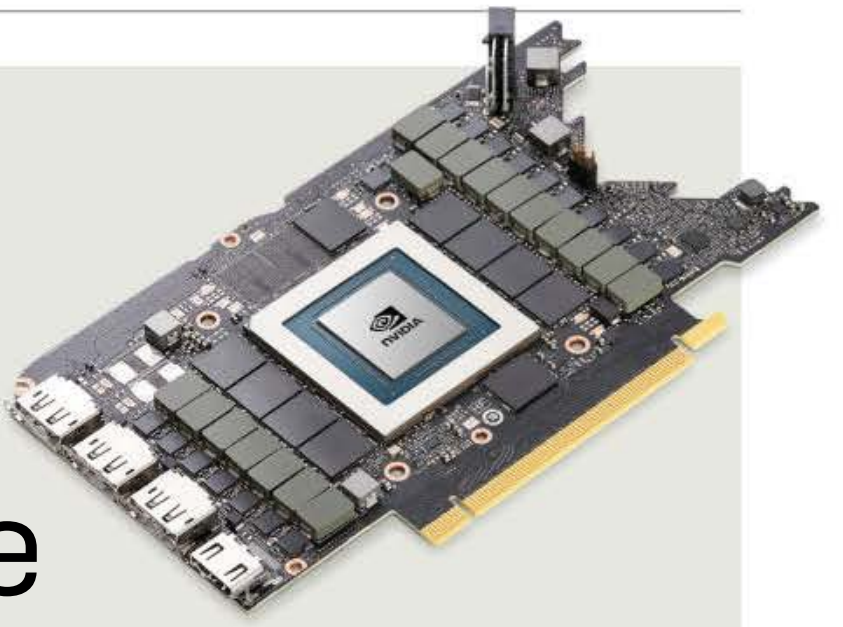


Jarred Walton

TECH TALK



Nvidia's Ampere Doubles Everything

IT'S BEEN TWO YEARS since Nvidia launched a new graphics architecture. The previous Turing GPUs ushered in the era of ray tracing for games—which, let's be honest, has mostly underwhelmed. With the next-gen consoles also adding ray-tracing hardware, however, we expect things to pick up in that arena. Ampere aims to "fix" what went wrong with Turing, mostly by throwing more hardware and performance at the problem.

There's a saying from the days of DOS: Wait for the point release, or the inevitable first service pack. That was about software, but there's a corollary for PC hardware: Skip the first generation of any radically new hardware, or don't set your hopes too high. Turing was Gen1 ray tracing. Ampere is Gen2, and it's looking like an absolute beast.

Nvidia has doubled just about everything. Let's start with transistor counts. The TU102 GPU found in the RTX 2080 Ti had a then-impressive 18.6 billion transistors (via TSMC 12FFC 12nm). GA102, which is used in both the RTX 3090 and RTX 3080, tips the scales at 28 billion transistors, fabricated on an optimized Samsung 8N 8nm process. Yeah, it's not quite double, but it's a much bigger jump than the 50% increase from GP102's 12 billion. More important is how you use those transistors.

GA102 has six GPCs (graphics processing clusters), each with 14 SMs (streaming multiprocessors). The RTX 3090 has 82 SMs enabled, while the RTX 3080 has 68. That's already a healthy step up, but what's inside the SMs has been massively updated. There are 64 dedicated FP32 CUDA cores, but where Turing had 64 more INT cores, Ampere has 64 more CUDA cores that can do FP32 or INT operations—potentially double the FP32 performance per SM. The RT cores have also been enhanced, doubling performance per RT. There are situations where the new RT cores are even faster, but real-world performance is closer to 1.7x faster than Turing. The Tensor cores received even more upgrades; instead of 4x4x4 matrices (128 FMA ops per cycle), they work on 8x4x8 matrices. But there are half as many Tensor cores per SM (four instead of eight), so FP16 Tensor ops performance per SM only doubles.

> The RTX 3080 checks in at 29.8 TFLOPS, the RTX 3090 hits 35.7 —nearly triple the RTX 20-series

Memory is 10GB of 19Gb/s GDDR6X on a 320-bit bus for the RTX 3080, or 24GB of 19.5Gb/s GDDR6X on a 384-bit bus for the RTX 3090. That's 760GB/s of bandwidth for the 3080, and 936GB/s for the 3090. Not quite double that of the 20-series parts, but a significant jump. Oh, and the GPUs are clocked at 1,700MHz boost for the 3090 and 1,710MHz for the 3080, though in tests I'm seeing more like 1,850–1,900MHz.

Going back to the CUDA cores, Turing allowed for fully concurrent FP32 and INT operations, while Ampere is either concurrent FP32 and INT, or FP32 and FP32. That means theoretical TFLOPS has skyrocketed, so the RTX 3080 checks in at 29.8 TFLOPS and the RTX 3090 hits 35.7 TFLOPS. That's nearly triple the RTX 20-series, but in games the performance is more like 70% higher for the 3080 versus the 2080 (at 4K ultra—it's less of a jump at 1440p, and very much CPU limited at 1080p). That's because games typically have around a 65/35 split between FP32 and INT workloads. In other words, two-thirds of the FP32/INT CUDA core time is spent on INT operations.

Above: The GA102 GPU sits at the heart of the RTX 3080 and 3090, and it's a performance monster.

What does it all mean? More performance at lower prices. The RTX 3080 is around 35% faster than the 2080 Ti, and sometimes twice as fast as the RTX 2080 FE, all for the same $799 price as the outgoing 2080 Super. The 3090 replaces the Titan RTX, delivering more performance for $1,499—a $1,000 drop. Or, Nvidia claims the RTX 3070 will beat the RTX 2080 Ti in performance and cost $499.

Now we await AMD's response. Current indications are that the top Big Navi (Navi 21) GPU will fall between the RTX 3070 and 3080 in performance, but closer to 3070 pricing. It's a great time to start thinking about a new GPU upgrade.

Jarred Walton has been a PC and gaming enthusiast for over 30 years.

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DOCTOR

THIS MONTH THE DOCTOR TACKLES...

> Onboard Sound
> Sleep Resume Issues
> Transfer Setup

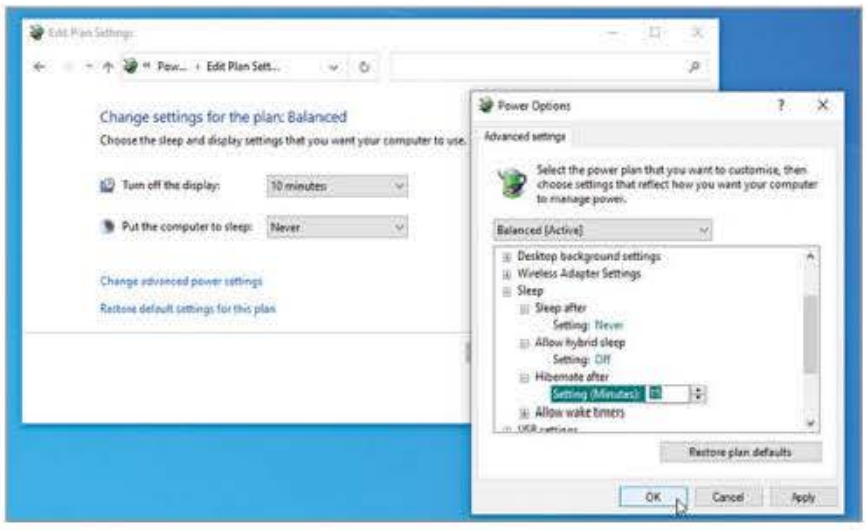
Move Windows 10 License

I have three licenses attached to three computers. One is an OEM laptop. The other two are Pro licenses I purchased. It's time to upgrade one of the Pro machines, which will be a full rebuild, making the jump from an Intel 6700K to AMD. How do I transfer the license? Thanks.

–Painflame

THE DOCTOR RESPONDS: The key is to link your Pro license to your Microsoft account as a digital license. Open "Settings → Update & Security → Activation" on the PC you're replacing and check the activation status—if it simply says "Windows is activated with a digital license" you should see a prompt for "Add an account"—click this and follow the prompts to link it to your Microsoft account.

Once done, perform your rebuild and install Windows 10 in the usual way, remembering—if you had one—to enter the same product key during installation. After it's done, head back to "Settings → Update & Security → Activation" and, assuming the activation hasn't miraculously worked, click "Troubleshoot" to open the activation troubleshooter. Follow the prompts, selecting your old PC as "This is the device I'm using right now" to transfer the license across. After clicking "Activate," the process should be done. If you run into any errors, check https://support.microsoft.com/en-us/help/10738 for what to do next.



Hybrid sleep can cause problems on some hardware.

Onboard Sound Issue

Last December I bought (rather than built) my first PC: an Ibuypower Intel i9-9900KF on an MSI MPG Z390 Gaming Edge mobo. In April, the sound suddenly stopped working on the mobo's line-out socket—it still works fine through the monitor's aux-out connector or optical-out on the mobo. I've exhaustively troubleshooted the problem—even swapped out the mobo for an identical replacement—and the problem persists. Do you have any ideas? And a suggestion for a soundcard? This is the first build I haven't used one.

–Bill Many

THE DOCTOR RESPONDS: This can happen when the default output device is changed, but the Doc reckons you'll have already tried that ("Settings → System → Sound," click "Sound Control Panel" to verify what playback devices are listed—typically your mobo's aux-out will be listed as "Speakers" and should be enabled and the default device; select it and click "Properties" for more options).

As you're not impressed with the onboard sound anyway, rather than continue wasting energy on troubleshooting you should trade up to a dedicated soundcard. Assuming you're unable to plunder a card from one of your previous builds, then the Sound Blaster Z PCIe ($105, www.newegg.com) is proven technology with a raft of good customer reviews behind it. It's optimized for gamers too. If that's too rich, then the Sound Blaster Audigy RX 7.1 PCIe model ($69.99, www.newegg.com) is a good budget alternative.

Sleep Resume Problems

I'm running a Ryzen 5 1500X on a Biostar X370GT mobo, with Windows 10 Pro on a SanDisk A400 256GB Gen3 PCIe M.2 SDD. My problem began after I installed two TeamGroup T-FORCE DELTA RGB 8GB DDR4 2400 sticks, at which point my PC forgot which hard drive to boot from when it resumes from sleep.

It wakes up, goes through the motions, attempts to repair all my drives without finding any problems, but can't remember where my boot drive is. So, when the blue boot screen pops up, I shut it down. Then, after pressing the power button, it boots normally. Is this a problem with my RAM

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↘ submit your questions to: doctor@maximumpc.com

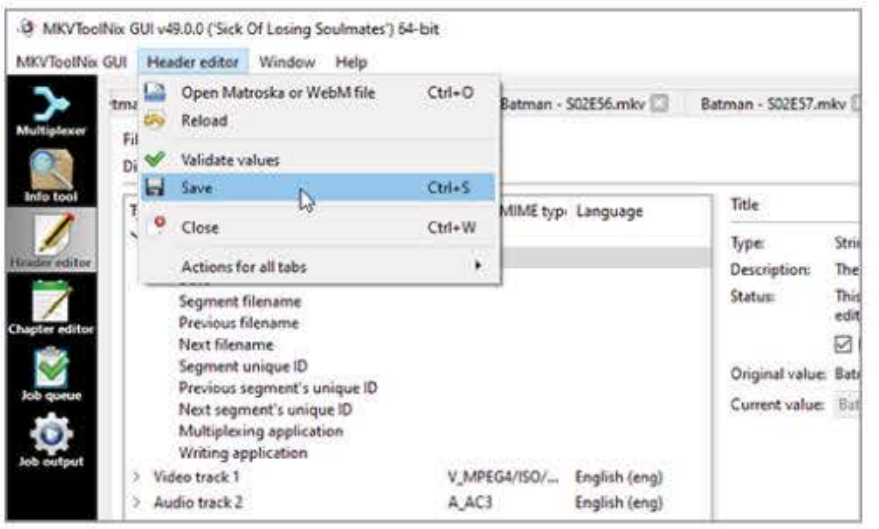
not being compatible with first-gen Ryzen boards?

–Neo Lithic

THE DOCTOR RESPONDS: The first troubleshooting step is to swap out the new RAM for old (or simply remove it if it was added to existing RAM) to see if that resolves the problem. If it does, then you may be able to resolve the issue by ensuring the BIOS is updated to the latest version—despite a maddening lack of release notes, it appears that at least one memory-compatibility update has been issued since the stock BIOS was released. Make sure you choose the right variant—there are four X370GT models listed on the Biostar website. Also, don't expect miracles—while the memory-compatibility list for the X370GT includes three TeamGroup RAM modules, none are your specific model.

Whether this solution works or not, before you consider replacing the RAM, explore some other updates. If you've never updated the firmware in your drive, install the SanDisk SSD Dashboard (http://bit.ly/MPCNovsandisk) to see what's available and whether it helps at all. Also, make sure your chipset and storage drivers are all up to date.

If the problem persists, consider disabling hybrid sleep in favor of hibernation. Hybrid sleep uses a mixture of RAM and your hard drive to store your machine state in, while hibernation makes exclusive use of your hard drive, so may prove more reliable. Press Win + X, choose "Power Options," click "Additional power settings." Select "Change when the computer sleeps" followed by "Change advanced power settings." Expand "Sleep" and you should see a "Hybrid Sleep" option. Expand this and set it to "Off," then set "Sleep after" to 0 (which effectively sets it to never) before setting "Hibernate after" to the same value you'd originally set for sleep. Finally, add the "Hibernate" option to the power menu by clicking "Choose what the power buttons do" followed by "Change settings that are currently unavailable." Tick the "Hibernate" option in the Power menu before clicking "Save changes."



Strip unwanted metadata from MKV files with mkvtoolnix.

Plex Movie Label

I've enjoyed your mag for as long as I can remember and loved the one on setting up a Plex server. My issue is with movies I periodically download from the internet. If there's no title in the file properties, Plex takes the title from the filename, which works fine as I rename my movies to the correct syntax.

However, some sites place all kinds of information into the Title field, which I can read by right-clicking the file in File Explorer and choosing "Properties → Details tab." Plex takes the information and places it in my database. While I can usually change this to whatever I choose within Plex , sometimes the field is locked, and I can't edit it. I've looked online and can't find how to unlock the title field to change it, so it reads correctly in Plex. Can you help? **–Lisa Lukens**

THE DOCTOR RESPONDS: The Doc suspects this may be a problem with MKV files rather than MP4 ones. Plex will often prioritize any information it finds in the file's metadata over its own online scraper, so the solution is to strip this out of the file itself, then rely on the correct naming convention—title (year).mkv in the case of movies—to allow it to correctly identify the file and download the metadata from your database.

With MP4 files, you can strip the metadata in File Explorer from the file's own properties tab under "Details": just click "Remove Properties and Personal Information," select "Remove the following properties from this file" and then Ctrl-click the elements you want to remove—in this case, the title. Click "OK" to complete the job.

Sadly, this approach won't work for MKV files; instead use MKVToolNix (www.fosshub.com/MKVToolNix.html). Launch the app and choose Header editor, click "Open Matroska or WebM file" to open your offending file. Expand "Segment Information" and select "Tile," then tick the "Remove element" box before choosing "Header editor → Save."

Once done, reopen Plex and update your library. If Plex doesn't automatically update the metadata with the correct info, move the file out of the folder, update the library, then move it back in and update again to fix the problem.

Transfer Setup

Hi Doc, I've been using a desktop PC for the last six years. It's running Windows 10 Pro 64-bit, and I'm looking to buy a new PC with the latest technology. I've got a lot of software installed on my current PC and would like to know if I can clone my current drive and install it on my new PC. Trying to reinstall all my software would be a trial, as I can't find many serials. I realize I'd have to install the new drivers on the clone drive for the new PC, however, can this be done? **–George Criezis**

THE DOCTOR RESPONDS: In theory, yes, although it's not recommended and may not work. It assumes your current PC's copy of Windows is a full-blown license and not an OEM one, as you'll need to transfer the license across to your new PC, along with all your software, settings and data. There are no guarantees: The Doc has inadvertently booted an old Windows installation onto a new PC and seen first-hand how, after a couple of blue screens and numerous automatic driver updates, it settled down to allow reactivation and appear to work okay for the very limited time he kept it going, but you may not be so lucky.

There are two alternative—and superior—approaches you can try, although neither is free. The simplest and cheapest involves Laplink PCmover (https://web.laplink.com)—$39.95 for Home version, or $59.95 for Professional. This works best if you hang onto your old PC to set up a direct transfer between it and a new PC (USB is quicker than network cable).

An alternative is to use a drive-imaging tool that supports restoration to different hardware. One such app is Macrium Reflect Home Edition ($69.95 plus tax, www.macrium.com/products/home), which comes with Macrium ReDeploy for this very task. It's a convoluted process involving Windows PE, and you'll need to first install Macrium Reflect Free on your old PC to take a drive image. Once done, search https://knowledgebase.macrium.com for "ReDeploy" to follow a step-by-step guide of the transfer process. A bonus of using Macrium is that you'll be able to continue using the program to keep your PC backed up.

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Testing Nano Coolant We get hands-on with one of the world's most advanced liquid coolants

WE KNOW WHAT you're thinking: "This is odd." And you're right—it's not something we'd usually cover here at *Maximum PC.* It's not a gaming rig specced out to some arbitrary number set by the management bods, nor is it a deep-dive into the latest technological architecture from the likes of Nvidia (next issue—don't worry!). No, this is something we've never done before: A case study and the chance to test something that very few people can get their hands on.

So, what are we talking about? Well, we're heading back into the world of tubing and water blocks to take a look at one of the most radical types of coolant being developed and grown today: Mayhems' 6nm XTR. Yep, you read that right—this coolant is synthetically grown in a lab. It's unlike any coolant we've ever seen before.

However, there's a few problems we need to overcome before we get to the testing phase. Firstly, as the Maximum PC office is currently shut, there's only one machine we still have access to that's capable of performing the tests we need: Our console-esque pink PC, which was designed for its aesthetics, with usability a secondary consideration. So, it doesn't have a proper drain port nor a fill port, and we've got some serious conversion problems to solve.

But before all that, let's dive into the history of liquid cooling, how it developed, and where it's likely to go from here.

1ltr XTR
TREATED
1ltr XTR
TREATED
PHANTEKS
Eisblock GPX-N 2080 Ti / 2080 M02

Kings of Cooling

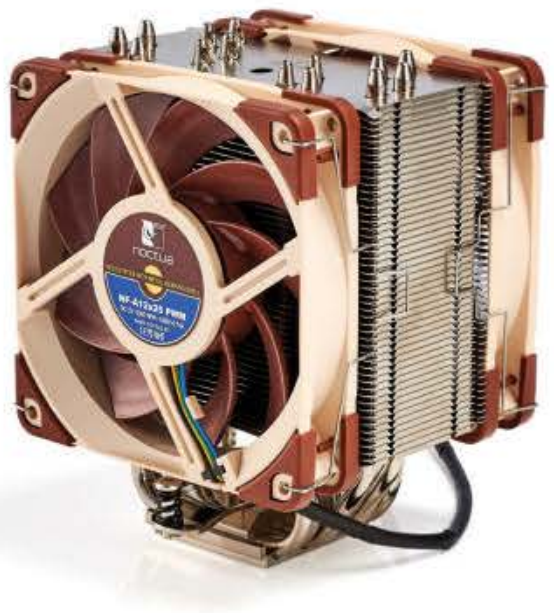
The problem with PCs

Behold, the UNIVAC 1 in all its room-filling glory.

NO MATTER HOW you look at computing performance, it always boils down to electricity, tolerances, and heat. Those three factors have stymied unlimited power over the years. Diminishing returns are rife within this enthusiast hobby of ours. As transistor count goes up, gate width decreases, more voltage is applied, and heat increases, the need to cool components becomes more important to ensure they remain within their operating temperatures. To draw heat away from the processor and into something that can dissipate it into the open air has been of prime importance since the personal computer became a thing—in fact, even before that, with supercomputers.

The basic principle behind cooling any PC component is that you need a form of heat exchange to take heat from the system and dump it into the surrounding environment. Nowadays, you have a handful of options. Firstly, you could go with low-powered, efficient components (such as the Raspberry Pi), which can be passively cooled. Or you could run with an air tower that thrives off heat pipes, vapor chambers, and the brilliance of convection. You could also go with a basic form of liquid cooling in the form of an AIO (all-in-one) cooler from the likes of Corsair, NZXT, Cooler Master, et al. Or you could build your own complete custom liquid-cooled loop to chill everything within sight, albeit at far greater expense and risk if something goes wrong.

Noctua's air towers are some of the most advanced phase-change designs around.



THE BASICS

Almost all of those options (bar passive cooling in ultra-low-powered chips) rely on a form of heat exchange or phase change to remove that excess heat. Take your standard CPU tower, air-cooled with a fan. By design, they typically have a solid, flat copper or nickel base, with heat pipes emanating out and up into a tower, which is then covered in an array of fins. This is then cooled by a fan, that's either pushing or pulling a stream of cooler air over the fins, drawing that heat out.

This works through the power of convection. Each heat pipe or vapor chamber houses a small amount of liquid. When the processor is under load, it heats this liquid, which evaporates, forming a gas. Drawing the heat with it, it rises up through the heat pipe toward the fins. Here, cool air passes over the fins, drawing the heat out of the gas through the fins. The gas then condenses, changing back to a liquid, and flows down to the base of the heat pipe, ready to start the procedure all over again, very much in a loop. This is, in essence, a form of phase-change cooling, although not quite to the degree of some more extreme methods achieved by using a proper vapor condenser.

A liquid-cooled loop follows a near identical principle, just scaled up. Instead of heat pipes, you have tubing; rather than a copper base, you have a water block; instead of fins on a tower, you have a radiator; rather than vapor or condensed liquid, you have coolant; and instead of convection, you have a pump. This gives you a larger thermal capacity overall, and increases your ability to cool components with a larger thermal footprint.

In fact, it works in a very similar way as the cooling system in a car's engine. A pump pushes coolant around (or anti-freeze, in the case of a vehicle); it then enters a water block, where it heats up, then moves on through a radiator, which has cooler air passing over it, thanks to a fan or two, which draws the heat out of the coolant, ready for it to begin the cycle again. The advantage is that the coolant typically has a far higher thermal capacity than the liquid in CPU fan towers, and there's a greater surface area for cooling the coolant, thanks to the radiator.

THE BEGINNING

Liquid cooling has been around for almost as long as there have been computers in one form or another. In the '50s and early '60s, supercomputers such as the UNIVAC 1 and IBM's System 360 were making waves by dipping into the chilly stuff to keep their temperatures low and performance high. By the '80s, the majority of server mainframes and supercomputers were being liquid cooled. It was only in the mid '90s, however, that it began to take off in the world of personal computing, with modders and overclockers reaching for the hand tools to build their own CPU water blocks from

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The testing kit comes with four bottles of treated and untreated coolant.

scratch to ramp up their performance. As always with overclocking, with more volts comes more heat. And thanks to everything from plumbing fittings to car parts, and homemade blocks to jerry-rigged radiators, the world of consumer liquid cooling came to be, and it wasn't long before companies such as XSPC, EKWB, and Alphacool began to capitalize on the market in the late 2000s.

Since then, designs have changed quite dramatically for blocks, parts, and components, but one thing that's stayed relatively stale over the years is the coolant, especially if you want ultimate performance. For the absolute elite, the be-all and end-all answer has always been distilled or deionized water. In its purest form, it was the most thermally efficient coolant out there, and readily available, too, at a super-low price. With a touch of biocide or a silver coil, it's fairly resistant to gunge and bacterial build-up, and with a splash of dye, you can even make it look quite pretty, albeit at the cost of performance.

As PC gaming developed, and the enthusiast community grew, with various YouTubers showcasing liquid cooling to the community, major brands such as Corsair, Thermaltake, and more have jumped on board with their own brands of bespoke custom liquid-cooled parts. And yet, coolant still hasn't advanced that much, certainly not when it comes to outperforming pure water. We've seen opaque coolants, such as Mayhems Pastel, and particulate coolants, perfect for photo shoots and show builds, plus various dyed coolants, but nothing has come close to beating H_2O.

MAYHEMS 6NM XTR

This is where XTR comes in. As you know, Mayhems is a company that we frequently turn to here at *Maximum PC* for coolant for our liquid-cooled builds. In fact, its coolants are somewhat renowned for quality and performance the world over, and the firm has been in the industry for well over a decade, developing and working on a wide range of coolants for PCs. The small British company was the manufacturer behind some of EKWB's coolants until relatively recently, and now it produces all of Corsair's coolant for its custom liquid-cooled line, too.

That means it's got some serious clout and technological knowledge behind it when it comes to the world of thermodynamics. When Mayhems' owner, Mike, reached out to *Maximum PC,* offering us the chance to test some of the company's XTR coolant, we could hardly refuse. "Why is that?" you might ask. Well, XTR is quite possibly the most advanced coolant we've ever seen. In fact, in testing, the current 6nm variant has been shown to outperform water by 9–10 C in some scenarios. That's a big difference in the context of cooling. What's more, XTR is entirely grown (yes, grown) in a lab, it doesn't contain any glycol whatsoever, and it's 100% synthetic.

Liquid cooling is now commonplace.

Now, Mayhems is being very tight-lipped about the manufacturing process, for obvious reasons, but what we do know is that these 6nm particles are grown to size, and XTR is an industry first. No other company has managed to create a coolant that has such small particles on a mass scale, and managed to keep it suspended, as can be found with XTR. In fact, Mike explained to us that the aims of XTR were simple:

- **To create a coolant that needs no biocide or other forms of active chemicals that die off over time.**
- **To have a 100% light-blocking capacity that lasts longer than 10 years.**
- **To absorb heat better than anything on the market.**
- **To be able to withstand temperatures that no other coolant is able to and still keep working.**

All of these goals have been achieved according to both Mike's and multiple other beta testers' results. In fact, it's so effective that we've even seen video evidence of it absorbing and blocking a hit from a 6KW fiber laser dead in its tracks. And the way it behaves with RGB and LED lighting in a system really makes you realize just how special this stuff is—but more on that later.

It all sounds great, but we were a little apprehensive about giving it a try for a number of reasons. Firstly, this is the world's first 6nm particle coolant, so it does make us a little nervous when it comes to handling it. To give you some idea how small 6nm is, a red blood cell can be up to 7,000nm wide, a strand of DNA is around 2nm wide, and that nasty virus going around measures 100nm. So this is small, really small, which means there'll be plenty of rubber gloves involved. Secondly, it's expensive; we haven't been given an accurate figure as to how much it costs to produce, but it's currently listed on Mayhems' store page as $45 per liter. Ouch. And finally, we needed to find a decent system to convert into a test bed. However, with a bit of Dutch courage and some soothing words from Mike himself, we took on the challenge, and here's our first look at what it's like to be a beta tester in the world of the hyper-nano.

Reconfiguring the Pink PC

Our console-killer needs some love to get it ready for testing

LENGTH OF TIME: **2–3 HOURS**

LEVEL OF DIFFICULTY: **COMPLEX**

OUR $3,333 PINK PARIAH has had its fair share of knocks and scrapes since we built it pre-lockdown, and it's in dire need of a renovation and some key component adjustments before we can inject any new coolant into the thing.

At its heart this machine has an AMD Ryzen 5 2600X six-core, 12-thread processor, an Asus ROG Strix GeForce RTX 2080 OC Edition graphics card, 16GB (2x 8GB) of Corsair Dominator Platinum RGB DDR4 @ 3,200MT/s, and a 1TB WD Black PCIe 3.0 M.2 SSD with heatsink, all inside a Phanteks Evolv Shift X (sadly no longer for sale), and powered via a 750W Corsair SF750 80+ Platinum PSU.

Back in its heyday, it was no slouch in the performance department (especially for living-room gaming), but with the advent of the RTX 3000 series, Intel's 10 series CPUs, and AMD's Ryzen 3000 series, it's now somewhat long in the tooth. However, the thing it has always done really well is produce heat. And that's something we absolutely need to test out here. With the panels on and dust filters in place, this tiny system often hit 85 C on the GPU alone during long-term intense gaming sessions at 4K.

When this editor's future spouse got fed up of it being in the living room and told him to move it upstairs, we removed one of the rear glass panels and pulled off the dust filters from the sides with the radiators attached to improve airflow, and this dramatically affected temperatures—under-load GPU temps topped out at a meager 59 C compared to that aforementioned 85 C, with CPU temps

hitting 69 C max. Neat, and that's just adjustments to intake air, plus space to exhaust that heat.

THE UPGRADES

So, what needs fixing? Well, the problems lie in both the usability of the machine for draining and filling, and some potential issues that may arise in the future in the form of the water blocks we originally attached to the CPU and GPU.

When we built it we decided to use Phanteks' latest liquid-cooled water blocks. Everything else—frosted tubing, pump, reservoir, RGB rings, and radiators—came from Alphacool. For our coolant, we went with Mayhems' Pink Pastel.

The problem is that the water blocks on the CPU and GPU have developed microfractures around the G1/4-inch ports. We think this is due to user error, because we used ethanol to clean the blocks during the original photo shoot. Using alcohol on plexi typically causes it to shrink, then develop microfractures. Over time, they can lead to full-blown leaks. Not good.

We also need to add a decent drain port at the bottom of the system, and preferably an aeration port at the top as well. For all of this we reached out to Alphacool to get some additional gear in to reconfigure the loop for our new tests. This included a new CPU block, a new GPU block, and a few new fittings to add an aeration valve. But that does mean we need to fully drain, strip, and reconfigure the system ready for the tests.

INGREDIENTS

PART		STREET PRICE
CPU Block	1x Alphacool Eisblock XPX CPU Satin Clear	**$65**
CPU Lighting	1x Alphacool Aurora XPX Digital RGB Frame Black	**$18**
GPU Block	1x Alphacool Eisblock GPX-N Plexi Light RTX 2080 Super M08	**$120**
T-Block Fitting	1x Alphacool HF Connection Terminal TEE G1/4 Black	**$14**
M-M Extension (small)	1x Alphacool Eiszapfen Double Nipple G1/4 Black	**$9**
M-M Extension (tiny)	1x Alphacool HF Double Nipple G1/4 Black	**$7**
90-Degree Extension	2x Alphacool Eiszapfen L-Connector G1/4 Black	**$14**
Dual 45 Extension	2x Alphacool Eiszapfen angled adaptor G1/4 Black	**$14**
M-F Extension (small)	1x Alphacool Eiszapfen extension G1/4 Outer to Inner Black	**$9**
Tubing	1x Alphacool Eisrohr 13/10mm Plexi HardTube Satin 80cm 4pcs	**$38**
Total		**$308**

01 OF MICROFRACTURES AND MEN

HERE WE HAVE a prime example of what we're talking about with regard to those microfractures. These have been developing slowly over time on the block, ever since the photo shoot, progressively getting worse, but as this rig isn't used often, they've not been at the top of our list of priorities. You can see the fractures are emanating from the G1/4-inch ports themselves—this is obviously where there's a considerable amount of pressure being pushed down and where the plexi glass is weakest. Top tip: Don't use alcohol wipes on your plexi blocks.

02 DRAIN PORT CANDIDATES

THIS IS OUR FIRST CANDIDATE for a drain port location. Thanks to the design of the Alphacool radiators, there are multiple G1/4-inch ports on both sides. This is the slim 120mm radiator we have in the "bottom" of our case, next to the PSU. The 120mm fan there effectively sits below the chassis, stuck between the case and its detachable feet. In a perfect world, we'd disassemble the entire machine, drill out the plate, and attach a 90-degree fitting and a ball valve. However, the radiator has an additional port, facing out on the other side, which could be a better solution, and it doesn't require any modding. The only problem is that if a ball valve is used there, it will stick out the back of the case, and you won't be able to reattach the side panel (or tempered glass window).

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03 AERATION VALVE

ONE OF THE KEY PRINCIPLES involved when it comes to draining a liquid-cooled system is the movement of air and pressure. Gravity helps you move some fluid from a pressurized system, but if you don't have air passing through it, it's a very slow process. In systems with both a fill and a drain port, usual best practice is to open the drain port (draining the coolant out into a bucket), and open the fill port as well, so air passes through and the coolant flows out at a much faster rate. Because our system's fill port is located in the middle of our PC, this does present some issues when it comes to draining. So, we're adding an additional aeration valve (effectively a T-block fitting, with a plug on top of it) at the very top of our rig, to help the draining process.

04 SYSTEM DRAINED

TO DRAIN OUR SYSTEM, we moved to it a sink, carefully unplugged the bottom port on the radiator, and quickly attached a length of soft tubing, placing the end in the sink. Then we opened up the fill port on the reservoir and began to drain the coolant as best we could. As our fill port is in the middle of the loop, we attached a clean length of soft tube to it, then blew into it, to encourage the rest of the coolant to leave the system. Only do this if you're replacing your coolant with one that contains a biocide, because it can introduce bacteria to the system and encourage organic growth. Once as much of the coolant was out as possible, we started to disassemble the various parts of the machine, including the GPU. G1/4 ports on different manufacturers' blocks can be in different locations, so it's no guarantee that, when swapping blocks, the tubing will fit back in place afterward, but it's handy to keep them nonetheless.

05 BLOCK SWITCH

WITH THE GPU OUT, we then turned to the CPU block, and removed that as well, being extra careful because the RGB cable plugs directly into the case itself. Here is where we made our first mistake, because we accidentally got some coolant on the board. We did the best we could, mopped it up with a microfiber cloth, then used a heatgun to dry the board off—however, this would come back to bite us later. Then we placed in the new Alphacool block (a satin block to match our tubing), and attached the DRGB frame as well, and plugged it into the header close by. After that, we were lucky, in that all the tubing runs we'd used in the previous build fitted perfectly back into position, with some help from a bit of flexibility from those angled fittings.

06 T-BLOCK INSERTION

WE THEN REMOVED the topmost tubing run (now hanging loose since the removal of the GPU), and placed it to one side. With the 90-degree fitting out, we installed a small male-to-male extension, then screwed in a T-block—a giant extension fitting that has G1/4 threads at three locations. You can also get X-blocks and Y-blocks. They're usually designed for adding drain ports, or splitting flow off in parallel loop designs, where coolant flows through two separate runs at once. We're using it as a pseudo 90-degree fitting, then placing a plug on top to act as an aeration valve. There's a slight issue with the fact that it's not rotary, as once it's secured, that's the angle you get. Fortunately, the panel pass-through fitting it's attached to can rotate in the hole we originally cut out of the case, so it's not an issue. If you use one, pair it with a male-to-male rotary extender, to avoid the problem.

07 GPU BOO-BOO

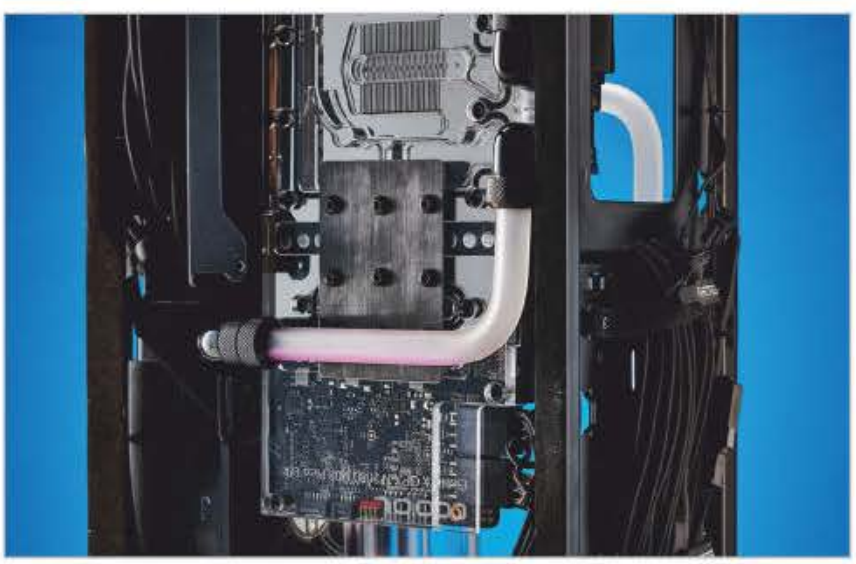
WE'RE NEVER ASHAMED TO ADMIT when we mess up, and this was the second major boo-boo of the build (the first was getting coolant on the mobo). In short, midway through the first day's photography and system stripdown, we realized we'd ordered the wrong GPU block for the graphics card. The Asus ROG Strix RTX 2080 OC uses a custom PCB, and we'd ordered in the block for the reference design instead. D'oh. A quick call to Alphacool, and it managed to ship us the correct part in less than a day. Fun fact: The expedited shipping almost cost more than the block itself. You can see the differences between the two GPU blocks: The one installed, the M08, is far larger than the one we originally requested (M02), and comes with a cut-out for those MOSFETs that the other doesn't have. You win some, you lose some.

08 GPU BLOCKS

WE'VE FINALLY got the correct water block in, so it's time to install it on the card. How do you go about that? Well, the first thing we had to do was remove the old Phanteks block. We've got the entire card removed from the case and plugged up, so next on the list of things to do is remove as many screws as we can. Remove the backplate first, and that gives you access to the main screws that hold the GPU block in place. Once that's out of the way, it's time to carefully remove the card from the block, then proceed with a quick clean-up and removal of the old thermal paste and thermal pads. After that, installing the Alphacool card is a piece of cake. Use the included color-coded thermal pads in the positions indicated by the manual, add a blob of thermal paste to the GPU, then carefully pop your graphics card on to the water block, lining everything up. Add the remaining pads to the backplate, screw it down, and you're good to go.

11 MISSTEPS AND ADJUSTMENTS

LOOK AT THAT PINK COOLANT in the bottom tube. This is a fresh tube that we've just bent and installed, and used an extension fitting to get to sit right, and it's got coolant in it. Where from? The radiator. It's all too easy to fail to properly clean coolant out of a system. In this case, though, it's intentional, as Mayhems requested that we test the coolant under all sorts of conditions: With a flushed loop, with gunk in the system, with some coolant still in there—the idea is we look for any user scenario and see how the coolant responds. The second thing to note is we've got away with reusing the same tubing that connects the GPU to the T-block. The only thing we needed to do was shorten one end and add an extension fitting to the other. The angles are very precise, and it would have been a nightmare to bend a fresh tube.



12 TIME FOR SOME MAYHEM

AS THIS COOLANT IS DIFFERENT from most, and the size of the particles in it are smaller than blood cells, we've taken some extra precautions. Equipping ourselves with a decent pair of latex gloves, we carefully pour the XTR coolant into our fill bottle over a sink, secure the cap on the bottle, and head back to the machine. We remove the plug from the 90-degree fitting on top of our reservoir, and remove one of the plugs from the top of the res (to act as our fill port). We add a length of clean soft tubing to the 90-degree fitting. This is going to be used as a last resort to move the coolant around the loop if necessary by blowing into it. According to Mayhems, XTR is very effective at killing off any potential bacterial growth. Then it's a case of filling the reservoir, sealing the caps, and powering the pump off a separate power supply to cycle the coolant around the system.

09 WAIT! THERE'S A PROBLEM

WITH THE OLD GPU BLOCK, we used the backplate that came with the standard air cooler. This retained the RGB lighting and kept the card quite slim. However, with the Alphacool block, you have no choice but to install the backplate that comes with the card. The problem is that it extends the GPU block out back, as it has thick thermal pads to help dissipate heat from the back of the memory chips and other VRM parts. This would be fine in any other build, but our reservoir is in a fixed location and can't be moved. Basically, the GPU wouldn't fit back in its slot at all. To get around this, we took inspiration from last issue's Hydra Mini build, and unsecured the PCIe riser cable that comes with the Shift X, attached it to the card pre-installation, then secured the card in place at the back, so it can rest on the reservoir without contacting anything or creating any conflicts. Annoying? Very.

10 GRAPHICAL ALIGNMENT

AT LAST, WE HAVE THE GPU in position—it was a bit of a squash and a squeeze, but it's in now and not touching anything. We've also extended the fittings on the front radiator to give us a little extra room, and that tubing run that goes from the front radiator to the graphics card is going to be redone as well (the original setup had a slight crookedness to it that annoyed us). There's a little wiggle here now, but we're not too worried about it, because once the tubing runs are all in place, and the fittings secured, that should help keep it in its position. It's still got the two PCIe notches in place as well, and the screws above it, too, so it's not all that bad.

13 ODD COOLANT

WITH THE SYSTEM PRIMED, we notice that it's a lot pinker than we thought it would be. This is no doubt in part to that pink pastel coolant being trapped in the radiators from before—ideally, the whole system would need a few flushes to get the bulk of the coolant out, but we sadly didn't have time during the shoot (a proper flush requires the loop to be running for a good 24 hours). Nonetheless, the way this coolant reacts with light is something else. As you can see, the light ring we attached to the reservoir emits a green glow, and the coolant immediately around that absorbs it and changes color, while it's a lighter pink in the rest of the system. Change it to any other color and you see the same result. In fact, you can see this even better in our frosted CPU block, up top, in the next shot. It seems the particles themselves reflect the light wavelengths—brilliantly so.

14 OFF-CAMERA PROBLEMS

WE MENTIONED we made two major errors during the conversion process for this rig. The first was requesting the wrong GPU block; the second was that we got coolant on the motherboard. A quick glance at this picture and you'll notice that the Corsair Dominator Platinum memory is cycling through its RGB rainbow preset, in a similar manner to the CPU block (the reservoir light is controlled via a small in-line remote). At the time of the shoot, we believed that small spillage on the board had managed to get some particulate into some of the memory traces and was causing the board to short, stopping us from configuring it. We left it for a couple of days extra after the shoot to try to let it dry out further, but to no avail. On a hunch, over the course of a weekend, we drained the system entirely, and disassembled the top part of the build, near the motherboard, to take another look. After reseating the CPU and memory, then refilling the system with one of our other bottles of coolant, lo and behold, the system powered on and displayed properly.

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Conversion Complete

THE PROBLEM WITH this type of build is that reseating the CPU to troubleshoot a problem involves draining the rig entirely of—in this case, particularly expensive 6nm—coolant, cleaning out as much as you can, getting enough microfiber cloths and paper towels together, then disassembling the entire top half of the loop just to get to the processor. Then you have to reassemble it all, refill it, and see if it works. If this is your only system, it's an absolute nightmare.

The reality is, although it was an interesting challenge to convert this build, it's not a very practical system. Swapping out blocks and coolant at the same time led to problems. What we should have done was swap the blocks earlier on, tested it again, long before the photography dates, drained it after we knew it was all working, then filled it again with the XTR coolant for our experimentation.

To be really thorough, it would have been better to have gone for a far simpler system. The Shift X is an interesting chassis, and to liquid-cool in it is as challenging as builds like this go, but it's not very representative of a normal liquid-cooled system, nor is it particularly easy to maintain, drain, or even move around.

THE RESULTS

So, how much difference did XTR make? There was a significant improvement, but not as much as we've seen from others who've used it. Performance was solid across the board—temperatures dropped significantly, in some cases by up to 6 C compared to the pastel coolant. That's not quite as high as we've seen some beta testers get (there have been reports of a 9–10 C drop compared to deionized water), but we have some theories as to why our results might be lower.

The biggest difference we saw was when we were using the Shift X build with the rear glass panel and dust filters in place. This is our sort of baseline test, for what this system ought to look like, and where it gets hottest. In this setup, the temperature drop across the GPU and CPU varied 4–6 C from test to test. Just for a pure coolant swap, that's pretty solid. However, remove the glass panel and dust filters, and the difference falls to about 2–3 C. Still an improvement on what we had previously, but not quite as dramatic.

We have a hypothesis as to why this is the case. Firstly, the system isn't fully flushed. There's still a lot of the old pastel pink sitting in the loop. That coolant had been in there for almost a year when we drained it, so it wasn't exactly fresh, and that means the XTR coolant is effectively diluted. That's a problem on our part.

Secondly, we believe a lot of XTR's performance depends on the maximum thermal capacity of the loop. With liquid cooling, we recommend that you have a minimum of 120mm of radiator surface area per component you want to cool; double that if overclocking. Combine that with fans, airflow, internal air setup, pump speed, and reservoir capacity, and you end up with the loop's maximum thermal capacity. Removing our rear glass panel and dust filters dropped temperatures dramatically compared to if we ran with the case sealed. This suggests that our positive pressure setup with the Phanteks fans doesn't exhaust heat fast enough. Take the side panel off, and all that heat can escape, as the positive pressure from the intake fans pushes it out—all of a sudden, temperatures drop significantly.

The theory is that XTR is far more efficient at transferring heat into the radiators than standard coolant. When you're at your thermal limit within a loop, the best thing you can do is move heat to a radiator as fast as possible, then transfer it into the fins to be expelled or cooled by the fans. With our panel off, the internal temps were far lower naturally, thanks to that release of internal hot air. With the panel on and internal temps far higher, XTR moves heat away from the blocks and into the radiators at a far quicker pace than a standard coolant, so we see a bigger drop in temperature.

That means if you're looking to cool a 12-core processor and an RTX 2080 Ti off of a single 240mm skinny radiator, XTR should far outperform a standard coolant, or even water, because at that level, the temps should be much higher and the coolant should perform much better.

ON TO THE NEXT TESTS

We're not satisfied with our results just yet; we want to see how it responds when the system's flushed fully, and is free of pastel residue. To that end, we're going to blitz the system and crack open another bottle of the white stuff, and see how this coolant performs over long periods under load. Rumor has it that it improves with age, and temps drop further the longer it's in a system, so we'll have to check that out, too. We also we want to build the "Impossible Machine": An ITX chassis, a single skinny 240mm radiator, a tiny pump and res, a 16-core processor (if not more), and the best/hottest GPU we can get our hands on. It will take a while to get the parts together, but once done, it should prove once and for all whether Mayhems' XTR is truly the king of coolants.

BENCHMARKS

	Mayhems Pastel—Panels Off		Mayhems 6nm XTR—Panels Off	
Idle CPU Temperature	38		**37**	
Idle GPU Temperature	**31**		32	
Prime95 Blends Test	69	36	**66**	**35**
Cinebench R20	66	**35**	**64**	**35**
3DMark: Fire Strike	74	61	**71**	**58**
TechARP x264	69	39	**66**	**36**
Assassin's Creed Odyssey	62	67	**60**	**64**

	Mayhems Pastel—Panels On		Mayhems 6nm XTR—Panels On	
Idle CPU Temperature	39		**37**	
Idle GPU Temperature	**32**		33	
Prime95 Blends Test	78	41	**73**	**37**
Cinebench R20	76	39	**70**	**38**
3DMark: Fire Strike	81	75	**76**	**70**
TechARP x264	80	44	**76**	**42**
Assassin's Creed Odyssey	75	79	**71**	**74**

Best scores are in bold. CPU temp left, GPU temp right. All figures are degrees Celsius. 3DMark and Prime95 ran for an hour before the highest figure was noted. TechARP x264, Cinebench R20, and *Assassin's Creed* had three consecutive benchmarks run before final temperature noted. Temperatures monitored with HWMonitor. *Assassin's Creed: Odyssey* was tested on the highest preset at 4K. Local ambient temperature registered at 22 C, with humidity at 62%. Cool-down period was 30 minutes between tests, and fans were set to a fixed RPM of 50%. Aside from the XMP memory profile, there was no overclocking outside of stock parameters.

Our test system consists of an AMD Ryzen 5 2600X, Asus ROG Strix GeForce RTX 2080 OC, 16GB (2x 8GB) Corsair Dominator Platinum RGB DDR4 @ 3,200MT/s, a 1TB WD Black SN750 M.2 PCIe 3.0 SSD, and an Asus ROG Strix X470-I Gaming motherboard powered by a Corsair SF750 80+ PSU. Intake fans are 3x Phanteks PH-120MP PWMs, exhaust fan is 1x Phanteks PH-F140MP PWM.

NEXT-GEN DISTROS

Step right up: **Jonni Bidwell** is here to unveil the finest Linux distros around!

TAKE A MOMENT to cast your mind back 15 years to that pre-credit crunch optimism of the mid-2000s. Windows users were appalled by Windows Vista, and a new Ubuntu operating system was claiming that it could displace Windows—despite being based on the fiendishly inaccessible Linux, and thinking that orangey-brown was a good desktop color.

Well, Windows may not have been wiped out by Ubuntu, but Linux has developed in leaps and bounds since then. It's more usable than ever before, and key industry players take it much more seriously now. Thanks to Valve and Vulkan, we can play thousands of Windows-only titles on our Linux boxes. More companies than ever are shipping Linux on consumer hardware, too—your wireless hardware probably works with it.

Best of all, there's a fine range of distros to choose from. Ubuntu has always been a great place to start, but it's not to everyone's taste. Here, we present our pick of the next generation of distros, which is sure to ruffle a few feathers. Since making Linux easy is very difficult, we've got a section on usable distros, including our long-time favorite for beginners: Mint.

Next, we'll explore some of the best-looking distros out there that will give you a truly modern desktop. In particular Elementary OS, through its Pantheon desktop, is doing the unthinkable by making Linux simple, powerful, and—dare we say it—at least a little bit Mac OS-like.

Finally, we'll look at distros that are leveraging the latest in open source technologies. You might not want these technologies (or so it seems by the number of complaints about Wayland, Systemd et al), or you might not be able to use your favorite software with them easily, but these will shape desktop Linux in the years to come.

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Linux Milestones

Many battles were fought—and coffee urns emptied—to get distros to where they are today. Here's a quick recap

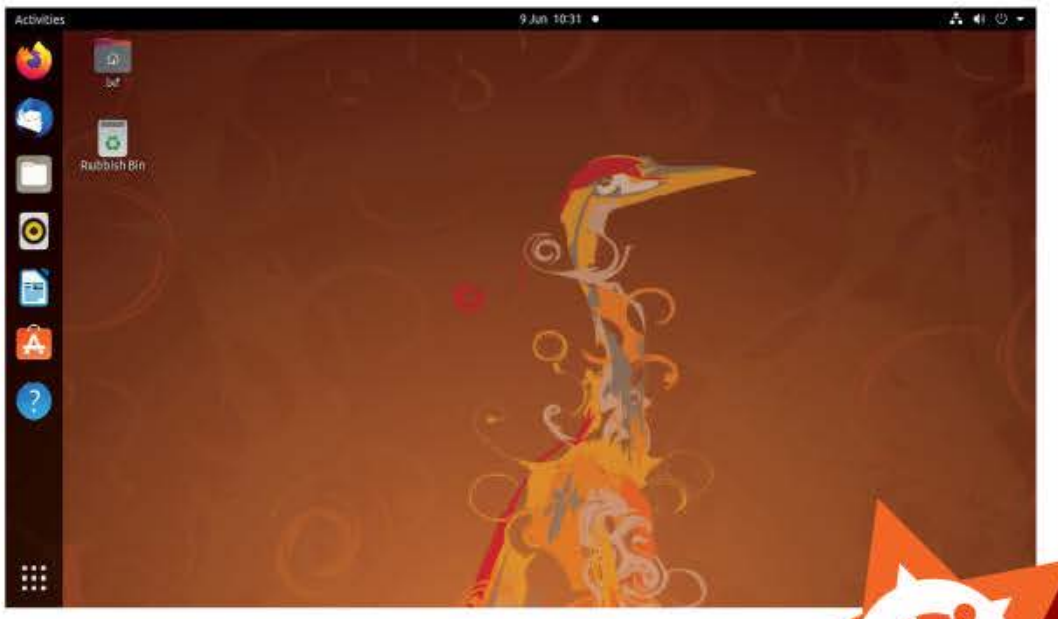
LINUX DISTRIBUTIONS have come a long way since the good old days. In the beginning, of course, there were no distros (actually in the beginning there was no Linux, and no space-time, then there was a big bang—but you get the point). You'd start with the kernel, somehow bootstrap a barebones system, fetch some GNU tools, mess with the make files, compile those packages, install them, realize you'd got your Make file wrong, tidy up the mess. Rinse, lather, repeat. It was great fun.

More often than not you had to get these things on CD or even floppy disk in the post, unless you had access to the internet (or a friend in a computer science department). Then in 1992 came SLS, which inspired Slackware and later frustrated Ian Murdock into creating Debian. Yggdrasil, the first Linux live CD, was launched shortly after SLS, which required a gluttonous 8MB of memory and a gargantuan 100MB of disk space. The first stable version of Debian didn't appear until 1996, by which time Red Hat Linux was on the scene, and all of a sudden people realized there was money to be made with Linux.

It's easy to overlook the contributions of those pioneer distributions, and other giants such as SUSE and Mandrake, and indeed those of lesser-heard ones, such as Conectiva (a distant ancestor of Mageia that popularized Linux in South America).

There's a tendency to just focus on Ubuntu as the great humanizer of Linux. And by the same token, there's a tendency to dismiss desktop Ubuntu today as a sideshow to Canonical's commercial success. Ubuntu continues to do great things for Linux, and is an excellent distribution for beginners and professionals alike. But what happened in the mid-2000s was pretty exciting. Suddenly, there was a version of Linux that anyone could use. It did everything that Windows XP did (except maybe talk to your wireless device). There was an office suite that could mostly open Word documents. Something was standing up to the Microsoft juggernaut...

Things are different now. Microsoft's attitude towards open source has changed, and desktop computing isn't the be-all and end-all it once was. The web is truly OS-agnostic, so there's no danger of say, your bank not supporting you if you use Linux. We take for granted the ability to watch Netflix or play games, but this would have been unimaginable on Linux systems just a few years ago. Today Intel, Oracle and even Microsoft (sort of) now have their own Linux offerings. A few stand-out distros have emerged that have brought genuine innovation, whether technical or ideological, to the Linux world. So let's have a look at some of them.



The Hardy Heron wallpaper (from 2008) was remastered for Ubuntu 20.04.

© UBUNTU

SOLVING PROBLEMS

Don't worry if you think something's not right with a particular Linux distribution. You're entitled to a full refund after all. Only kidding. In 2012 even the creator of Linux, Linus Torvalds himself, raged at OpenSUSE developers when he discovered that adding a printer (on his daughter's laptop) required the root password. Sometimes there are reasons why things are that way (in 2012 there wasn't the notion of a privileged local user; it's handled by systemd these days), sometimes it's a genuine bug, and sometimes you're just using it wrong.

These days Linus is generally calmer (except perhaps on the subject of L1D cache flushing), and his recently purchased development machine (a Threadripper 3970X which you can read all about on ZDNet at www.zdnet.com/article/look-whats-inside-linus-torvalds-latest-linux-development-pc) runs Fedora 32. And we'll talk about that later on. We'll also see how elementary OS is tackling unnecessary password requests over the page.

There are plenty of ways to get help with Linux, and thanks to its popularity it's highly likely someone has encountered your issue before you did. So your first act should be to always be to Google (or DuckDuckGo if you prefer) your problem. Beyond that, head to your distro's forums and search there. If you still feel like you've hit a new issue then describe it as best you can, and check the forum's guidelines about how to get and attach appropriate log files and hardware informations. Help the community to help you.

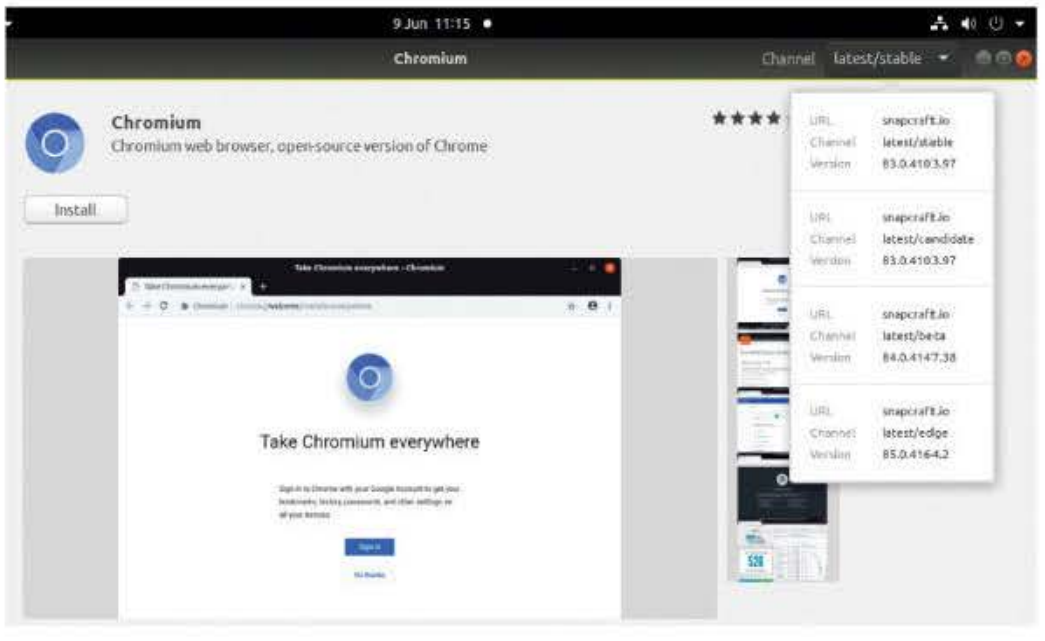
User-friendly Usability

Some Linux distributions go out of their way to make new users feel comfortable. We shine a spotlight on the more welcoming distros

LET'S LOOK AT LINUX MINT FIRST, which continues to be a favorite of ours. In particular, it's one that we still recommend to users who are taking their first steps with Linux. Initially (the 1.0 release in 2006 was a beta based on Kubuntu), it took the Ubuntu codebase and bundled flash and Wi-Fi firmware to make for a better out-of-the-box experience. It experimented with its own codebase for a couple of years, but then returned to Ubuntu's, and since then the two have always been package-compatible. It enables Mint to piggy-back off the treasure trove of packages in the Ubuntu repositories, while still providing its own experience.

When Ubuntu switched to its Unity desktop, Mint offered something more conventional in the form of its Cinnamon desktop (which first appeared in Mint 13). Cinnamon was initially based on Gnome 3, but soon became its own thing. For die-hard traditionalists, Mint also offered the then-fledgling MATE desktop a fork of Gnome 2. Both Cinnamon and MATE continue to thrive, while Unity has been abandoned by Canonical (though the latest version lives on in the UBPorts mobile OS, and the penultimate edition is still tended to by a small but loyal community). When Ubuntu 18.04 was released, sans 32-bit ISO, Mint went ahead and produced its own (32-bit packages were still built for 18.04, but this is not the case for the latest edition, so Mint 20 is 64-bit only).

We're still waiting for Mint 20 to arrive, and Clem and the team have remained largely silent about what to expect. In previous releases, it's been as much about what they've removed from Ubuntu as what they've added. For example, the "anonymous" telemetry information that you have to opt out of sending in Ubuntu is banished from Mint.



Chromium is only available as a Snap in Ubuntu. If you want it in Mint 20 then you'll have to fetch it manually.

As Ubuntu moved towards the Snap packaging format, some Mint users voiced concern about whether these would become the norm in Mint, too. They (unlike Flatpaks and AppImages) rely on a proprietary app store after all, which makes Canonical a sort of kingpin in the software-distribution ring. The team reassured users that Mint wouldn't contribute to this Snap monopoly. Last year they said they'd support Snaps as long as they were useful and "didn't become the de facto standard [for packages]." Now they've put their money where their mouth is. Try installing Chromium with apt in Ubuntu 20.04 and you'll find you get a dummy package that installs the Snap version. This is irrefutable evidence of a Snap usurping a traditional package, and something the Mint team won't stand for.

MINT 20 BETA INSIGHTS

As we write this, the first details of what to expect in the Mint 20 beta are starting to emerge. And one of the first is that no Snaps will be installed by default. The snapd daemon will also be absent, but you can add it if you wish. As a precaution, traditional apt packages will be blocked from installing snapd to prevent them acting, like Chromium's, duplicitously.

Linux Mint made waves by giving users what they want. It sounds harsh, and there are all kinds of complexities behind this, but other distros seemed reluctant to listen to their users. Alas, the most common gripe, "why can't it just work?" is alive and well today (though this applies to other OSes, and in fact all forms of technology). A sad trend that Ubuntu's accessibility inadvertently started was frankly unqualified users taking to bug-trackers and venting their rage. People would describe their problems (badly) in angry block capitals, they wouldn't supply log files or hardware information, they wouldn't attempt to pin down the problem, they would fail to do even the most cursory search for other people having similar problems or, worse, they would jump onto similar bug reports crying "me too!"—even though their issue was different.

Developers shied away from engaging with such reports. The canned response thanking these newcomers for their submission and referring to reporting guidelines has become ubiquitous. One place where Linux Mint excelled has been through its community helping each other, and developers engaging with that community rather than being bothered by them. Their "Newbie Questions" forum still bears the tagline "all gurus once were newbies" and is still for the most part free of more experienced users being condescending to newcomers' questions—even when those newcomers didn't read the helpful guide on how to ask for help.

© LINUX MINT

ENDLESSLY USABLE

Over the past decade, some Linux distributions have appeared that go out of their way to be more usable (and less breakable) by regular humans. One is Endless OS. Originally tied to Endless Computers's hardware (budget small form-factor PCs aimed at developing countries), the Debian-based distro is now available to all and comes in a few forms. The full desktop edition (available in seven languages) is a whopping 16GB in size, but includes the full text of Wikipedia, several Khan academy lectures, and Endless's own educational tools. It's aimed at offline and even off-grid usage. There's a more conventional desktop version (only 3GB), a VirtualBox image, and finally an image for the Raspberry Pi 4. Besides its hardware (including the Spark kids' laptop), educational contributions (such as its immersive Terminal Two coding tutorials, see https://terminaltwo.com), Endless has taken a particularly innovative approach to system updates.

Such updates are a necessary inconvenience, but Microsoft has turned a lot of people against it, most egregiously when it force-updated Windows 7 machines to Windows 10, in many cases breaking them. But also, unless you tell Windows 10 to do otherwise, it has a habit of installing large updates at shutdown time (no good if your computer is in the same room you sleep in) or at boot time (no good if you actually want to use your computer when you turn it on). Another sad situation is when disk space is low, large updates will download and not be able to install. In some cases (particularly cheap tablets) this can make them entirely unbootable.

Linux updates tend not to be so disruptive, but they do on occasion break things. This is particularly upsetting for new users, especially if they're confronted with a confusing error message and a busybox shell or worse, a blank screen. It's easy to blame these issues on user error, or the Nvidia driver, but people shouldn't have to learn all about chrooting and modifying system files just to get their desktops back.

Linux Mint conceded this and launched its Timeshift tool for rolling back updates. Endless OS goes one step further: The whole filesystem is updated at once. This so-called atomic upgrade uses OSTree, itself described as "Git for filesystems" (or in this case operating systems). Of course, this doesn't mean that every Endless OS device ends up with exactly the same filesystem (that wouldn't work unless every device was identical, hardware and software-wise). Rather, configuration files (say, everything in /boot and /etc) are layered atop the base OSTree image, and individual applications are installed as Flatpaks. You can roll back the entire OS to a previous version of the OS (just like you can switch Git branches) at the press of a button.

While the OS is based on Debian, you can't readily use apt and .deb packages (or any traditional packaging format) on Endless OS. The OSTree/Flatpak combo is a bulletproof platform because the root filesystem is read only. Even if the power goes out mid-upgrade, the previous incarnation of the OS will be accessible and the upgrade can be resumed. Installing an application won't break the base image because Flatpaks are self-contained. OSTree images are incremental too (only changes between versions are stored) so rolling back doesn't come with a huge disk space cost.

Mint gives users what they want: A traditional menu in the corner, a powerful file manager, and beautiful desktop backgrounds.

NEXT-GEN APP DISTRIBUTION

Flatpaks, Snaps, AppImages: They all seek to make it easier for developers to ship software in a distribution-agnostic manner. Whereas Snaps rely on a central app store, anyone can set up their own Flatpak remote. The Flathub repo (https://flathub.org) is a good place to find popular apps. Flatpaks are OSTree images too, which is why the two integrate so nicely in Endless OS. When you download your first (non-trivial) application on Endless OS (or your first Flatpak on another OS), you'll find that the download is very large. This is because it depends on a large runtime (e.g. Gnome) Flatpak. Once you have this you won't need to download it again for Flatpaks, which depend on it. These runtime Flatpaks are updated incrementally, so subsequent large downloads should be a rarity, and unlike deb packages there are no issues with requiring a particular version.

Fedora's Silverblue desktop distribution brings atomic upgrades to the Fedora ecosystem. Here, a hybrid packaging system, RPM-OSTree, is used so that the base OS image can be modified in layers. This is useful for installing low-level packages such as drivers and shells. Conventional desktop programs are installed this way, and there's also support for containerized workloads.

The Future Of Apps On Linux
Flatpak is a next-generation technology for building and distributing
desktop applications on Linux

Flatpaks and snaps also take the burden of packaging away from distros.

The New Generation

Check out these wonderfully crafted distros that give the operating system from a certain fruit-named company a run for its money

UBUNTU DERIVATIVES ARE A DIME A DOZEN. Some you could probably recreate yourself by installing a desktop and changing some default applications. But some are simply outstanding, taking the rock-solid Ubuntu base and adding unique and powerful features on top.

One example is Elementary OS which, through its own Pantheon desktop, brings a sleekness and simplicity that rivals Mac OS. Instead of forcing users to read manuals (which in many cases just raises more questions), one of Elementary OS's aims is to have minimal documentation. It aims to be sufficiently intuitive that users should be able to figure things out for themselves. Another of its design aims is "concision," keeping things simple and avoiding bloat. Finally, it strives for "accessible configuration"—not bombarding the user with options, or asking for information that could be obtained automatically.

This might sound like fluffy design speak, but when you see how the app indicators subtly convey useful information, how the infobars gently notify you of exigent situations, and how everything integrates so nicely, then you'll see that there's substance to it all.

CONTRIBUTING TO ELEMENTARY OS

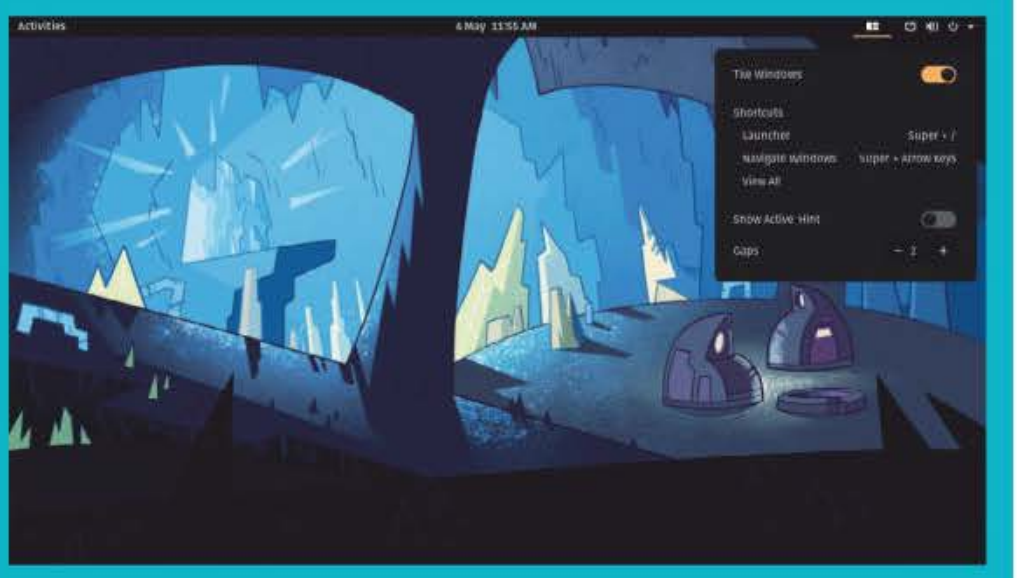
Elementary OS is not free as in beer (beer's free now?). It uses a pay-what-you-want model, and when you download it you're asked to make a contribution. Ubuntu and some others use this model too, and nothing bad happens if you select $0. There's nothing inherently wrong with charging money for software—even free (as in speech) software. It's even expressly permitted by the GPL. Elementary OS, in asking for donations rather than slapping on a price tag, is striking a balance. It's ensuring that people get reimbursed for their work, while at the same time making it available to all. If you disagree with that stance then you're under no obligation to use it. If you want to contribute in another way, you can help fix bugs or help users on the forum (as you can for any software). There's even a bug-bounty program, so if you're willing to pay for a feature (or would like to get paid for fixing something), subject to team approval and someone coding it, you can.

Fiscal models aside, Elementary OS is beautiful. The Plank dock gives easy access to commonly used applications, and the bundled ones all follow a uniform design. They're all coded in Vala, which makes them integrate easily with GTK (or elementary OS's custom superset of it, dubbed Granite). They're free of unnecessary configuration options, proving that sane defaults are possible. Most interestingly, many of them don't have an explicit Save option. They'll save as you go and reopen to the same state they were left. The AppCenter includes a section of curated programs that adhere to elementary's design philosophy and have been reviewed by the team, as well as everything you'd find in Ubuntu's erstwhile Software Centre (now the Snap Store). Flatpaks are supported out of the box too via a custom tool, Sideload. Unlike Apple's walled-garden approach, elementary OS makes it possible for adventurous users to brave the open source jungle.

BEHOLD, THE GORGEOUS POP!_OS

It would be remiss of us not to mention, in a spread about beautiful distros, Pop!_OS. We were thoroughly impressed by the 20.04 release back in April. Pop!_OS (we like most everything about it, bar the awkward punctuation) is made by Colorado-based Linux system manufacturer System76. Being an OEM, the team wanted to be able to ship an OS that was guaranteed to work with their hardware. But also, just like the other distros named in these pages, an OS that makes it easy for users to do whatever they want to do. Pop's desktop is much closer to Gnome 3 than what Mint, elementary OS and Solus offer, but don't be afraid. Likewise, don't be afraid that the latest release gives you the option to experience—in a very gentle way—the fun and joy of a tiling window manager.

Pop!_OS ships two editions: One featuring the Nvidia proprietary graphics driver, and one featuring open source drivers for AMD and Intel hardware. System76 has contributed an awful lot to Linux, including a Firmware Manager front-end for updating firmware via Fwupd. In Pop, this is integrated into the update tab in the Gnome Settings application. Naturally, this works with not only System76 hardware, but anything supported by Fwupd (which is quite a lot of hardware). Pop also has a bunch of tweaks for common gripes, such as multiple displays and hybrid graphics.



Pop!_OS comes with fine backgrounds, and this button opens tiling utopia.

As well as looking pretty and being a pleasure to use, Elementary OS is conscious about privacy. Onboarding, which debuted in the 5.1 release, offers to turn on location services or automatically delete temporary files (and optionally Trashed items). This launches on first run for each user (the new user selection screen is also neat, by the way) and also guides users to the documentation, Night Light settings, and AppCenter. Many users will have long-abandoned email clients, opting instead for the web-based offerings from their provider. But Elementary OS's Mail program might just spur those users to make their inboxes local again.

We're looking forward to Elementary OS 6.0, which will be based on Ubuntu 20.04, but the team snuck out a point release, 5.1.5, in June which brought yet more nice touches. Being asked for a password occasionally might not seem particularly onerous, but when you encounter the password prompt on a daily basis it gets tiring. Elementary OS aims to tackle this "authentication fatigue" through contextual authentication, or only asking for a password where it makes sense to do so. If your laptop (which typically only one person uses) asks for a password when you log in, then it shouldn't really need to ask you again when you apply updates, or even install new software. Likewise, you shouldn't be prompted for a password, for example if you just look at (but don't touch) firewall settings. You can follow all the contextual authentication work on Github at https://github.com/orgs/elementary/projects/74.

PARENTAL RELATIONS

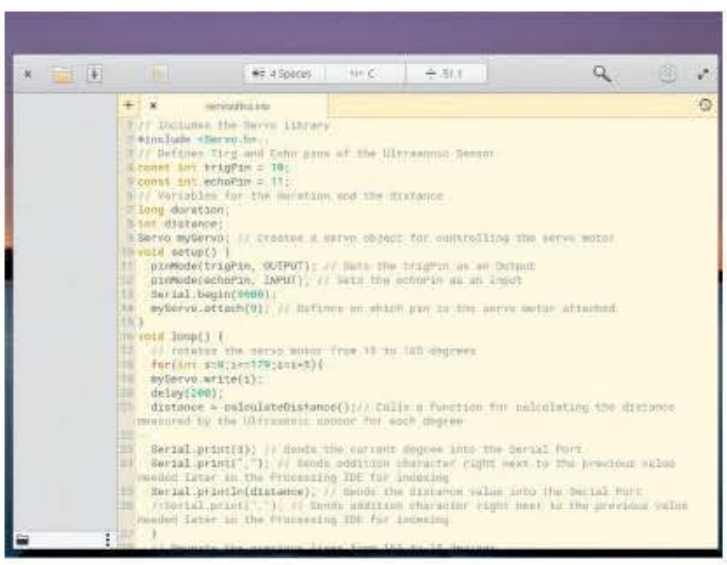
Desktop distros these days tend to all have a parent distribution. That might be something still going (Ubuntu, Debian) or something that's now defunct (such as Mandrake, where OpenMandriva and Mageia's roots lie). Such distros may be forks and have evolved their own codebase, or they may retain compatibility with their parents. Ubuntu is technically a fork of Debian unstable, whereas Mint is an Ubuntu derivative. Either way, it's rare that something totally free-standing comes out, which is why we must give credit to the Solus project.

Solus started life as Ikey Doherty's Evolve OS back in 2013. The project's package manager, eopkg, was a fork of PiSi from Turkish distro Pardus Linux. At the time (Evolve remained in alpha until 2015), most interest was centered around its unique Budgie desktop, which used Gnome 3's underpinnings to create a stylish yet traditional experience. Due to a trademark conflict (with the then-UK secretary of state no less) Evolve was renamed Solus, and Solus 1.0 was released at the end of 2015. By then Budgie had acquired its characteristic Raven sidebar (never again dig deep to tweak audio or see appointments with Lenore), as well as gathering a substantial following.

We had trouble deciding which of Solus's wonderful backgrounds to capture alongside the Raven sidebar, but cat pictures win every time.

In 2017 Doherty announced that he would be working full-time on the project, and Solus moved to a rolling-release model. The team had developed their own tool, ferryd, for rapidly deploying changes to their repositories. While not a strictly Solus project, work continued on the Linux Steam Integration tool (which forced Steam to use distro libraries rather than the antiquities found in its own runtime). Solus's driver management tool saw its first release, and Ubuntu Budgie (the desktop has long been available outside of Solus) became an official Ubuntu flavor. Ikey left the project in 2018, leaving it in the capable hands of his co-contributors, and the rest, as they say, is history. Budgie uses the semi-classical Brisk menu, designed in conjunction with Ubuntu MATE, and like elementary OS's Pantheon, all development is done in Vala.

The current Solus release, 4.1, comes in four editions (Budgie, Gnome, MATE and Plasma) and packs a range of multimedia features. For gamers, tweaks to the default file limits have been raised so that ESync can be used for better performance in Wine (or Proton, via Steam).



Code, Elementary OS's text editor, is beautifully crafted. We can't guarantee our Arduino code is likewise.

TAKING SOFTWARE SOLACE

Since Solus maintains its own repos, you won't find as many packages as in, say, Ubuntu's traditional .deb repositories. However, Snap is installed out of the box, so you can now avail yourself of the many offerings in the Snapcraft store. Flatpak and the Flathub remote are only two lines away, too:

```
$ sudo eopkg install flatpak xdg-desktop-portal-gtk
$ flatpak remote-add --if-not-exists flathub
```

Eventually these will be integrated in a new plugin-based Software Centre, and eopkg will be replaced by a next-generation package manager dubbed Sol. We're looking forward to the next Solus release, and indeed Budgie 11.

© SYSTEM76

Next-gen Distro Tech

Shiny and easy-to-use distributions are one thing, but which distros ship the latest Linux tech? Keep reading to find out

FEDORA IS RED HAT'S COMMUNITY DISTRO, where new technologies are honed before they make it into Red Hat Enterprise Linux's (RHEL) business. Fedora was the first distribution to see systemd, PulseAudio and SELinux (the NSA-contributed access-control mechanism). Those titles might send shivers down the spines of some, but like them or not they're here to stay. It's historically been the best way to experience unadulterated Gnome 3. That desktop offers the best Wayland experience, and Fedora was the first to offer Wayland by default (still with the shuddering?). So it's nothing if not a trailblazer distro.

The latest Fedora 32 even enables Firefox's new Wayland backend. And if you're feeling adventurous, enable Webrender and VA-API acceleration (which you can read more about on Martin Stransky's blog at https://mastransky.wordpress.com/2020/06/03/firefox-on-fedora-finally-gets-va-api-on-wayland). Indeed VA-API acceleration, which appeared in Chromium, debuted in Fedora's build over a year ago. So if Fedora receives new features, smoother browsers, why on Earth aren't you using it?

Occasionally Fedora is sidestepped because of its philosophy on software freedom. If you want proprietary software (including the Nvidia driver), or patent-encumbered multimedia codecs, these have to be added through a third-party repo such as RPMFusion or Negativo 17. The codecs issue is much less of a big deal nowadays. Popular streaming sites all use open formats (or at least, in the case of h.264, ones where an open source codec is available), and MP3 became a patent-free format in 2017. A free AAC codec was made available shortly after, so you can play all your ripped CDs from yesteryear out of the box. Or you could rip them again in a lossless, free format such as FLAC.

Third-party repos are only a click away in Fedora.

MAKE IT EASY ON YOURSELF

Setting up a traditional third-party Fedora repo requires a certain amount of effort—more so than setting up a PPA for Ubuntu, which is perhaps why it used to be a bit harder to find certain niche software for Fedora. Bear in mind that PPA overload was definitely responsible for the demise of many an Ubuntu install, and third-party builds should always be treated with caution. Nowadays a new technology, Copr, takes all the hassle out of building unofficial Fedora packages. Fedora even offers a Copr build service that will provide you with your own Dnf/Yum repository. Just upload a source RPM file, select your build targets, and you're done. Read more at https://developer.fedoraproject.org/deployment/copr/about.html. And, of course, more and more developers are turning to Flatpaks and Snaps (although the latter is disabled in Fedora's build of Gnome Software). So Fedora's comparatively small but carefully curated repos are no reason to shun it.

Fedora made the news recently with the announcement that Lenovo will be shipping laptops powered by Fedora Workstation. Writing on his blog, Christian Schaller, senior manager for desktop at Red Hat, said, "Our engineering team here at Red Hat has also been hard at work ensuring we can support these models very well, be that by bugfixes to kernel drivers or by polishing up things like the Linux fingerprint support." We often have queries about Linux on laptops from readers, and without a particular model to hand it's difficult to give solid advice on compatibility. Now, with laptop offerings from both Dell and Lenovo, we can direct users who want a rock-solid Linux offering out of the box there with confidence.

Christian has been adamant about "draining the swamp" over the course of his past six years at Red Hat. He's not talking about rogue politicians, either. Rather he's addressing desktop issues that for too long have been hastily patched over, where ground-up rewrites were required. He originally credits the phrase in this context to a talk by Jim Gettys, whose thoughts you can read at https://mail.gnome.org/archives/foundation-list/2002-May/msg00005.html. The latest Fedora includes Gnome 3.36 (the same as Ubuntu 20.04), and we're impressed with the distinct lack of swamps. You may have run into PulseAudio issues in the past, or you may not see any reason to use Wayland over X11, but these technologies were invented to solve problems. And solve them they do. You might also be interested that PipeWire, Wim Tayman's offering to unify media handling, is included by default in Fedora.

© RED HAT INC

PipeWire can now do pretty much everything Jack (the rather complicated interface for pro-audio setups) can, and the next step is to have it take on the duties of PulseAudio too.

If you've ever run Linux on a machine that doesn't have enough memory, you'll know that things can get very unpleasant very quickly. Apart from the slowness of using spinning-rust-based swap space (which is not an option on some systems), you might find yourself at the hands of the OOM (out of memory) killer. Applications will be slain more or less arbitrarily. Even worse, though, is when OOM can't react quickly enough and your desktop grinds to a halt. You can't move the mouse pointer, you can't switch to a virtual terminal, you probably can't even SSH in to kill things manually. We've run into this memory-pressure situation a few times when running one too many virtual machines—like when you're writing a big feature about lots of distros, and then it makes it late. Anyway... Fedora 32 includes the EarlyOOM daemon, which should step in before it's too late.

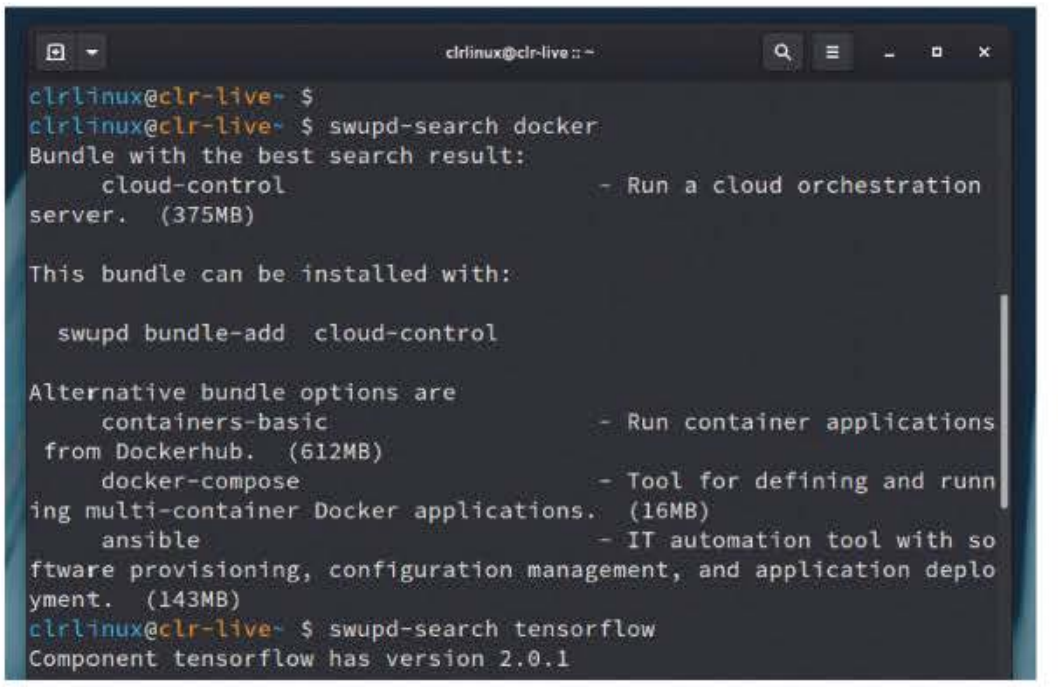
Fedora goes much further than the desktop. Naturally it has a server offering, such as its Flatpak and container-focused Silverblue desktop effort. But since Red Hat purchased CoreOS in 2018, it's now in charge of the distro formerly known as CoreOS Container Linux, now dubbed Fedora CoreOS. This will very likely be the future for managing container-based workflows securely, and in particular massive server deployments. And from the very big to the very small, in the form of Fedora IoT, its offering also serve the tiny things that will be running our cities and lives in the coming years.

A CLEAR WINNER

One distro we haven't covered much, but perhaps should, is Intel's Clear Linux. This is aimed at professionals using Intel hardware to do advanced things with container and cloud technologies. In its own words, it's "not intended to be a general-purpose Linux distribution." Be that as it may, it consistently scores favorably in Phoronix's tireless benchmark comparisons, and a desktop edition is available so you may want to check it out. Clear Linux abstracts application packages into the concept of Bundles, which enable a bunch of related programs to be installed at once. Since Clear Linux has its own repository, you might not find your favorite applications, but this is exactly part of the problem Flatpaks aim to solve, and installing the Flatpak bundle is easy.

Clear Linux bundles use compiler optimizations, enabling AVX-512 vector instructions on suitably endowed hardware. So, for example, if you're running TensorFlow, you'll benefit from kernel tuning, AVX routines in Glibc, AVX optimizations in Python, tweaked Numpy/Pandas modules, and finally optimization at the very top of the stack in TensorFlow's Eigen component. Clear Linux uses a stateless design concept, so the whole OS can be effectively factory reset by clearing /etc and /var.

This doesn't work on other distributions so please don't try it anywhere else. But do try all of the distros that we've mentioned here, and feel free to shout at/email us for not mentioning your favorite next-generation offering.


clrlinux@clr-live :: ~
clrlinux@clr-live~ $
clrlinux@clr-live~ $ swupd-search docker
Bundle with the best search result:
cloud-control - Run a cloud orchestration server. (375MB)
This bundle can be installed with:
swupd bundle-add cloud-control
Alternative bundle options are
containers-basic - Run container applications from Dockerhub. (612MB)
docker-compose - Tool for defining and running multi-container Docker applications. (16MB)
ansible - IT automation tool with software provisioning, configuration management, and application deployment. (143MB)
clrlinux@clr-live~ $ swupd-search tensorflow
Component tensorflow has version 2.0.1

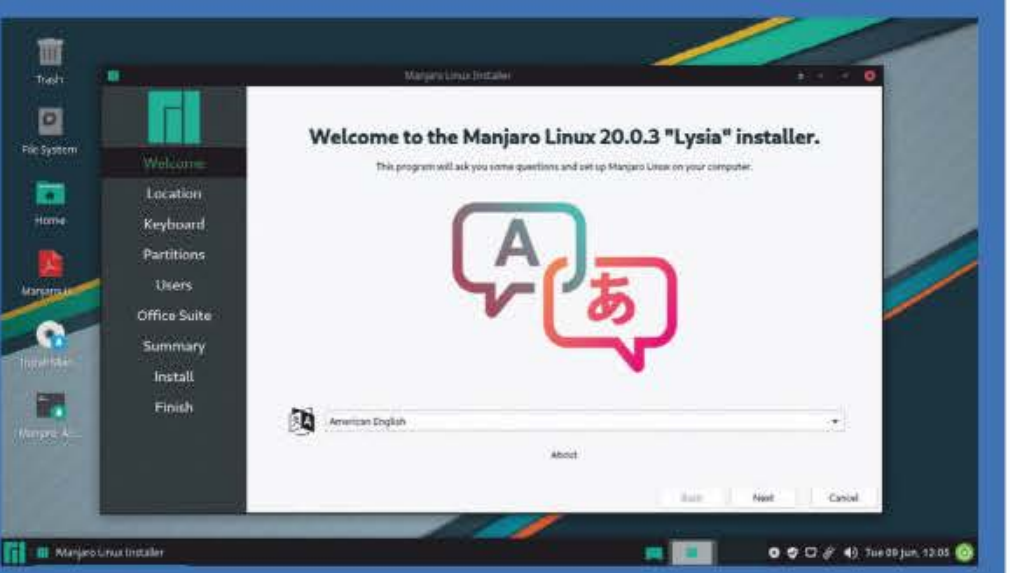
Clear Linux's swupd tool will get you bundles and have you controlling clouds in no time. There are some pleasing background on offer, too.

WHAT ABOUT ARCH?

Arch users may be shocked to find their distro of choice not mentioned in this page on new technology, and perhaps they have a point. But then so too might Gentoo or Linux from Scratch users, who also have access to the latest versions of everything, and can also compile it with whatever optimizations suit their CPU. We've focused instead on what distros offer out of the box, and with Arch, and more so with Gentoo, well, you barely get a box.

Manjaro has gone and done the unthinkable and made Arch Linux easy to use, and continues to be one of the most popular desktop distros around. Manjaro doesn't (directly) use the same repositories as its progenitor, since things move quickly on Arch, and Manjaro has a release cadence to follow (and a desire not to break its own packages). So you won't find quite the same bleeding-edge versions as you would in Arch, but the selection will be far from stale. And bugs that may have found their way into the stable Arch repos will have been ironed out by the time they reach Manjaro.

We like that Manjaro is bringing the Xfce desktop some attention. Lightweight doesn't have to mean light on features. And if you want a beautiful take on KDE's Plasma desktop ,you can also get that through Manjaro's Plasma edition.



Taming Arch Linux into something friendly? Well, now we really have seen everything!

MECHANICAL MYSTERIES

Dave Alcock takes you on a journey through the

KEYBOARDS ARE THE TRUE KINGS of input devices. They predate mice by almost 15 years, and thanks to companies like IBM—who set the standard in terms of the shape we know today—they have become perhaps the most easily recognizable and usable devices out there. In fact that tell-tale shape ensures that we can jump onto any PC we see and immediately know how to interact with it. If you think of a keyboard, you usually end up with an image of that standard 104/105-key ANSI layout imprinted into your mind.

Membrane, dome, capacitive, and scissor-switch keyboards still make up the majority of the keyboards that are out there in the wild today, mostly due to office and industry use. But before we go any further on this, what we will say is that these boards are perfectly fine products. There is a reason they are still being used in such vast numbers right now, and that's because they're cheap, accurate, and do the job they're designed to do darn well.

However, if you want to take it a step further, there are of course mechanical keyboards. These are nothing new—in fact most early keyboards were mechanical, with many phased out in favor of the cheaper options we just mentioned. The IBM Model M and Model F were the most sought-after of the older mechanical boards back in the day, and almost 30 or 40 years later these buckling-spring bundles of joy are still priced high enough to make your eyes water, coveted by many a coder and developer, even at *Maximum PC*. So let's dive a little deeper into the world of the mechanical keyboard.

realm of clickety keyboards

Mechanical Keyboards vs Everything Else

SO WHAT is the difference then? Well compared to other keyboards, mechanical switches are just that: Mechanical. They have a mechanism inside that moves and creates the action that sends the key-press signal. How this happens changes slightly depending on the switch type, but we will cover this in more detail later on.

The most common PC keyboards are membrane keyboards, while dome boards are still seen in industry quite a lot as well. Membrane keyboards use three layers, with the middle layer just there to space apart the top and bottom conductive layers so that they are not sending a signal to each other constantly. Once you press the key-switch down, the top and the bottom layers touch, complete a circuit, and send a signal. There is no mechanical action involved.

Dome keys are similar to membrane ones, but they have a dome that collapses to give the user some tactile feedback. There are also hybrids, known as memchanical (or membranical, depending on which marketing guru you listen to) keyboards, which are membrane boards that use a clicker to make them feel somewhat similar to mechanical keyboards. This keeps the price down but doesn't really give the user any benefits over the feeling of using the keys.

Mechanical switches are preferred over other switches because of their reliability, repeatability, and stability. If it has "ability" at the end, a mechanical switch probably does it better than the rest. Mechanical switches have far tighter tolerances, and they should feel more consistent between each other compared to other switch types. This enables users to really get a preference over what they like to use, and this can then improve productivity or performance in gaming.

Prebuilt vs Custom Keyboards

PREBUILT KEYBOARDS are off-the-shelf boards. These are the most common examples of keyboard on the market, and are by far the easiest to acquire. If you are new to mechanical keyboards, they are probably the best option, as well as for those who just want to buy a board and use it.

These include more popular brands, such as Corsair, Logitech, Ducky, SteelSeries, Razer, and many more. There is nothing wrong with these boards, and if you're an avid reader, you will see that these are the products that we use and review more often than not; they are readily available, and we can review them within certain parameters and testing criteria in a balanced manner.

Custom keyboards, on the other hand, are completely down to the user. They are bought either in parts or as kits, and can really be anything you want them to be. Custom keyboards also open up the possibilities to move away from the standard shapes, sizes, and layouts that we usually see, enabling you to create something more unique, ergonomic, or just bespoke to you.

A full-sized ANSI (American Standard) keyboard.

Full-sized keyboard without tenkey or numpad.

A 65 percent board gets even smaller.

60 percent boards: Now you have no physical arrow keys either.

40 percent is a little bit strange. These 44-48 key beauties are tiny.

Keyboard Sizes

FULL SIZE

A full-sized ANSI (American Standard) keyboard has 104/105 switches usually. The numpad on the right-hand side enables you to input numerical data easily, and companies can often further increase this size by adding macro keys or media keys to the board too. This means that the keyboard has a large footprint on your desk, often dominates your workspace, and can quite easily create an uncomfortable ergonomic working position.

If you use these boards, you will likely sit with your shoulders in a slightly wider position than with a better ergonomically designed board. This is a natural process, and one you do to ensure you don't hit the keyboard with the mouse. It's actually almost unnoticeable, as these are typically the boards many people grew up with, and it became second nature to use. These ergonomic problems only became apparent, as a curious discovery, once people started to use smaller keyboards.

TKL (TENKEYLESS)

As the name suggests, this is essentially a full-sized keyboard but without the tenkey or numpad. This reduces the size a great deal and also puts you into a better typing position, as now you can move the keyboard slightly towards the mouse, and your arms can be in line with your shoulders, with just a slight bend at the elbow creating the optimal sitting position. The difference isn't worth changing keyboards for though, and for many users the numpad is far more useful than having a slightly smaller board.

65% KEYBOARD

A 65 percent keyboard gets even smaller. This compresses everything down more, and you lose the physical F-key row as well. That said, you can still access them by using the FN key + the number keys, and the arrow keys are still physically there but are far closer to the right Shift/Control buttons. This is a good sweet spot for those who want a compact board but still want to use it without too many compromises.

60 PERCENT KEYBOARD

60 percent boards go one step further over the 65 percent ones, removing physical arrow keys too. Instead, the arrow keys are usually used with FN + IJKL or PL;'. You can also usually rebind these to other letter combinations, if you so desire. When it comes to our own custom keyboards, we have more 60 percent boards than anything else. It takes some getting used to, but once you do, workflow is just as fast, and you have a far smaller footprint on the desk. You can also shove a 60 percent keyboard into a laptop bag easily and carry it to events with you, meaning that typing away from the office or home has exactly the same feeling.

40 PERCENT KEYBOARD

40 percent is where it gets a little bit strange. These 44-48 key beauties are tiny. Boards like the Vortexgear Core 40 and the Planck have made these more popular, but they are still very much a niche, enthusiast product. They can still function as a full-sized board: Nothing is missing from it, you just have to remember the layers and the different functions. These are more of a hobby board, certainly until you get used to them, and even when you do, they're not easy to use in terms of functionality for anyone who does office tasks, or similar jobs that may require different punctuation on occasion. You'll spend more time looking for the right key than actually typing. We know from experience.

SPLIT KEYBOARD

As well as all the standard sizes we listed above, there are also split keyboards. These usually follow a TKL or 60 percent layout, but there are also full-sized split boards available too. Split keyboards link back to the ergonomics of peripherals, and instead of forcing your arms into a triangle like a standard keyboard would, these enable you to split the left and right sides apart so that you can sit optimally. There's a reason a car's steering wheel is still quite large: Sure it helps you to make turns, but the position it forces you to sit in with your arms is better for you. Split boards are based on a similar theory.

Keyboard Construction

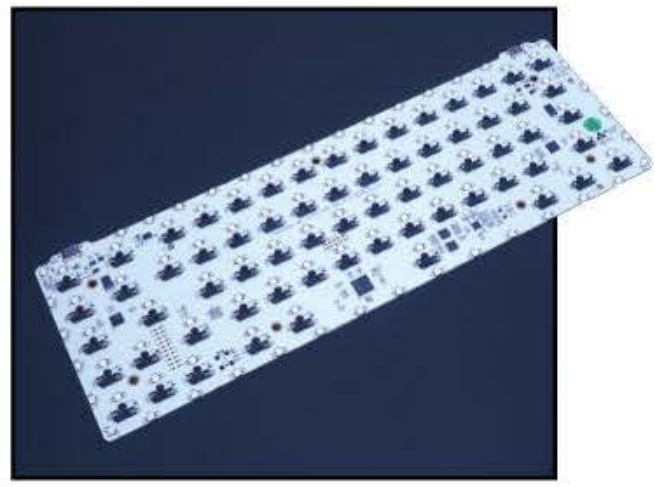
WE WON'T GO too much into the construction of a keyboard, but we do want to take a quick detour here, and it's something we intend to cover in much more detail in the future. In fact we'll be bringing you a series of guides on how to build your own custom keyboard later on this year.

Most custom and prebuilt keyboards use very similar components, certainly until you delve into the world of DIY componentry—which let's just say we'll stay away from for now. Purists often buy parts according to their preference on size, materials, and how well noise will resonate through them. Tinny, horrible-sounding switches are frowned upon, and when used even with a well-constructed keyboard can leave you with a hollow experience. So choosing the right parts is critical. If you're after a satisfying clunk, that perfect tactile component, and an almost-silent typing board, then a linear setup is the way to go. So what parts are there, and where do you begin?

CASE

The main part of the keyboard is the case or housing that will hold all the componentry. These are usually plastic, especially when you buy an off-the-shelf keyboard from mainstream brands, although in the custom market metal is starting to become more common.

For custom boards, resin, wood, and 3D-printed cases are also added to the mix. Basically anything that can be used as a case will be used as a case—even Lego. The case simply keeps the internals protected and enables you to create an incline if you so wish.



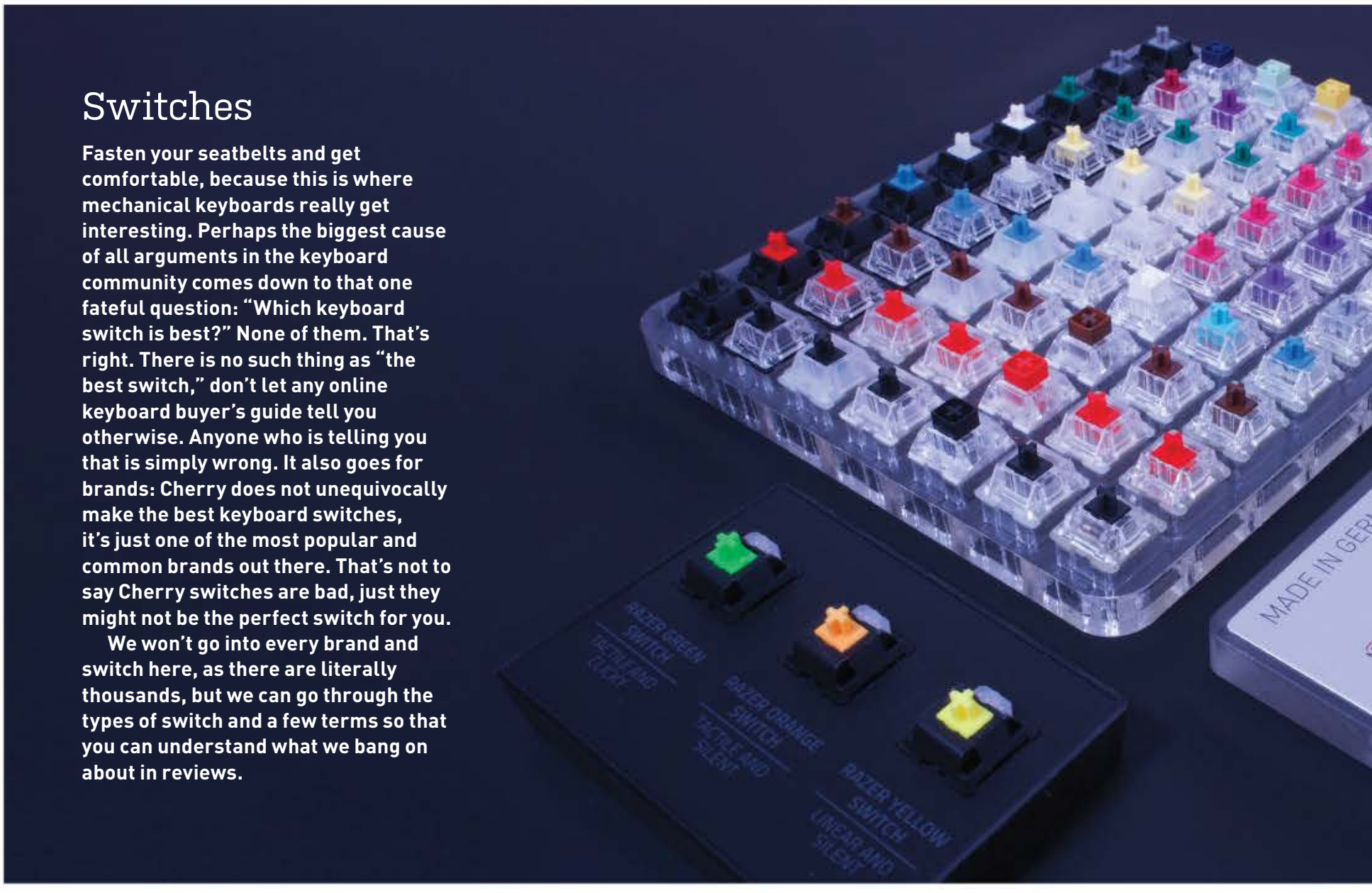
PCB

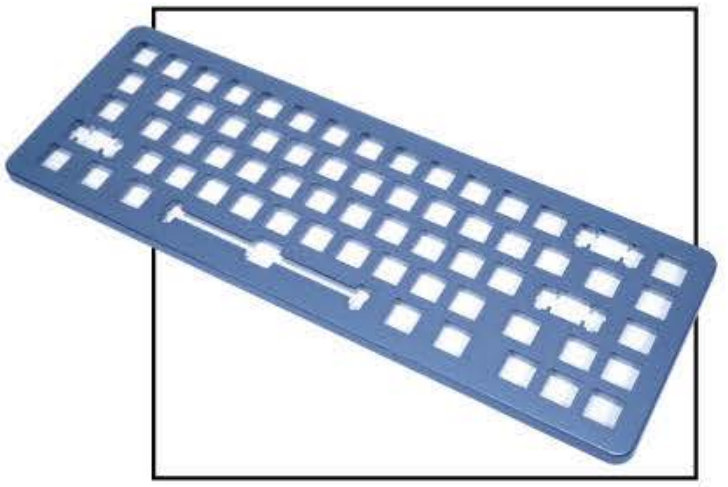
The PCB or Printed Circuit Board forms the electronics side of things. A PCB keeps everything neat and tidy and enables switches to be soldered to it easily. For off-the-shelf and most custom boards there is no real difference here. For component-level DIY boards, however, you can use remarkably simple PCBs or even do away with them entirely and wire everything by hand. Keyboards are not as complicated as they seem, and with a mini Arduino (or similar board), some diodes, a few resistors, plenty of switches, LEDs, and wires, you're basically good to go.

Switches

Fasten your seatbelts and get comfortable, because this is where mechanical keyboards really get interesting. Perhaps the biggest cause of all arguments in the keyboard community comes down to that one fateful question: "Which keyboard switch is best?" None of them. That's right. There is no such thing as "the best switch," don't let any online keyboard buyer's guide tell you otherwise. Anyone who is telling you that is simply wrong. It also goes for brands: Cherry does not unequivocally make the best keyboard switches, it's just one of the most popular and common brands out there. That's not to say Cherry switches are bad, just they might not be the perfect switch for you.

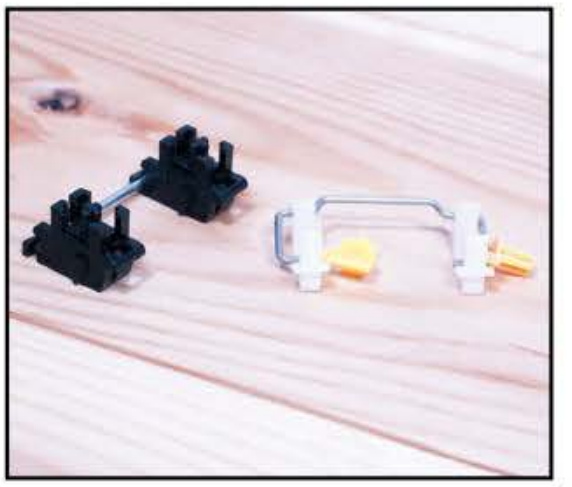
We won't go into every brand and switch here, as there are literally thousands, but we can go through the types of switch and a few terms so that you can understand what we bang on about in reviews.





PLATES

Plates are not seen in all keyboards but they exist in most, one way or another. There are many different types of plate, from top-mount to drop-in plates, but essentially all you need to know is that they are there to help with mounting the switches to the PCB, and also giving the keyboard some additional strength, noise dampening, and a desired level of flex. You might be incredibly surprised how different keyboard parts can completely change the noise levels and pitch of the switches that are installed, and a plate is one of those parts.



STABILIZERS

There are also stabilizers, and as the name suggests, these stabilize the keycaps so that they press down smoothly. These are only needed on large switches, such as the Spacebar, Shift key, and Backspace. There are a few different types of stabilizer, but the main two are Cherry style and Costar style. Unless you're building your own keyboard or you're thinking about modding a keyboard, it really doesn't matter which stabilizers are in your keyboard. If you do get a choice, though, try and stick with Cherry style as they are far easier to work with.

Popular Switch Brands

Cherry

Kailh

Outemu

Gateron

Zealios

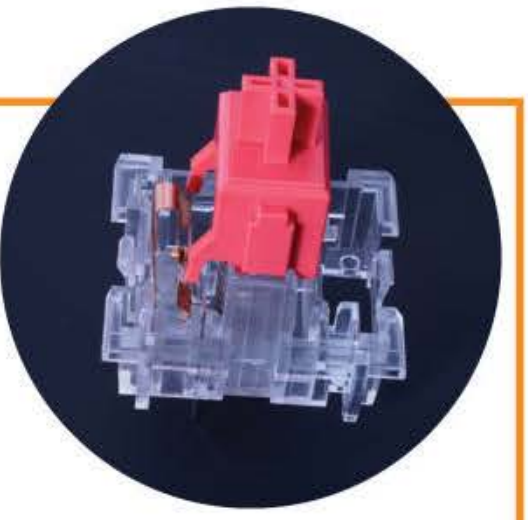
Romer-G

Titan

Topre

Alps

Razer



Switch Terminology

Different switches have other important statistics, beyond just the operating force.

TACTILE

Tactile means that there is a physical bump as you press the switch down. This is usually caused by the leaf and plunger interacting, or the plunger interacting on its own. Cherry MX Browns are a good example of this.

LINEAR

Linear switches are straight up/straight down switches. They don't have any tactile feedback at all. Cherry MX Reds are one such example.

CLICKY

Clicky switches do just as the name suggests: Click. This is what will annoy your co-workers in an open-plan office, and potentially give you a lot of enjoyment. The click usually coincides with tactile switches, as found in a Cherry MX Blue switch.

ACTUATION

Actuation defines at which point in the switch's travel it sends the signal that it is has been pressed. This actually changes between switches too. A switch such as a Cherry MX Speed Silver has 1.2mm until the actuation point with a total travel distance of 3.4mm. Something like a Cherry MX Blue will travel 2.2mm before the actuation point, and will travel to 4mm in total. This means that you don't actually need to bottom-out switches when typing, and you can keep noise down while still activating them.

Switch Construction

1. SWITCH HOUSING

The switch housing is the case that encapsulates all the internal parts. The tops are usually clear plastic now, so that RGB lighting is brighter. The bottoms can be any color. Most switch housings are very similar as they follow a standard, enabling you to swap them out easily. There are also two types of switch mounting. PCB-mounted switches have two additional prongs on the bottom of the switch that grips into the PCB. These make the switch more stable. Plate-mounted switches don't have these prongs as they grip onto the plate of the keyboard. This is usually a little bit less stable and can often give the switch an additional wobbly feel.

2. STEM

The stem on the switch is the little plastic plunger. The keycap attaches to this part. The most common stem is the Cherry MX style "+" shape. There are other kinds though: Topre uses an "O" shape, and in the past Kailh has used boxes. Now the majority of stems are using the Cherry + shape—it is far easier to get keycaps for these that fit a wide range of switches.

3. SPRING

The spring is what gives the switch its resistance or weight, and it is also this that resets the key after each press. The weight in these springs is measured in cN (centinewtons), but this is very close to grams: 1 cN = 1.019 gram (0.04 oz). This means that switch weights are often seen as 45g rather than 45cN.

4. LEAF

The leaf inside the switch is a thin piece of copper, folded in such a way that when the stem is pressed it will complete a circuit and send the signal saying the switch has been pressed. This can also be used to give the switch a tactile feedback, and make those signature clicky sounds. In some switches, however, click bars are used for this. Different thicknesses are used by different manufacturers, and the tolerances between them can change significantly, especially on cheaper switches, which will increase or decrease a switch's long-term durability.

SWITCH COLORS

You will often hear a color attached to the brand of switch, for example Cherry MX Greens, or Kailh Reds. This denotes the specification of the switch. The colors are not universal over different brands: A Kailh Brown is weighted at 45cN, whereas a Cherry MX Brown is 55cN. 10 cN is a big difference in terms of switch feel, so it is worth trying out a board with the weighting you're curious about before you commit to buying it.

Printing Types

DOUBLE SHOT

Double-shot keycaps are created by melting two different plastics and moulding them into each other. This means that you have one color as the main keycap housing, while the second color becomes the legend.

PAD PRINTING

Pad printing is probably the cheapest and easiest method of printing the legend, so it is more commonly seen on ABS caps. It is actually just a thin layer of paint on top of the main bulk plastic of the keycap, so it can be worn off over time. It does mean that more than just one color can be used, though.

DYE SUBLIMATION

A very expensive and time-consuming method is dye-sublimation printing. With this method, an image is printed onto transfer paper, then heated along with the keycap so it is transferred over. Although difficult to do, it does mean that you can use multiple colors. It also comes with some caveats. For one, you can't print onto darker keys very well, unless the image is darker than the key itself. Due to this, it is usually used with white or beige keys only.

Keycap Materials

KEYCAPS SIT ON TOP of the switch and are usually made from a form of plastic. There are many different types of keycap, from ABS to PBT, which can be printed on in different ways. We won't go through all the types, just the main few. It might sound complicated, but it really isn't when you break the terms down. The keycaps can change the sound of a keyboard immensely, and will affect the feel of the board and your typing experience.

ABS

These are the most common switches available on the market. The plastic is very soft and cheap, and they can have the text (legend) printed on them in many different ways, such as pad printing, or double shot.

PBT

PBT keycaps are seen as superior to ABS, because they don't usually get as shiny and are often thicker. They also have a nicer texture. Again, these can be double shot, but dye sublimation is often used as well.

Why Bother?

Why should you spend silly amounts of money on custom keyboards? Why spend $15 per switch when there can be anything from 40 to 120 switches on a keyboard, and then put $50 keycaps on them? Just, why?

Well, the answer really is a mix of searching for perfection, the desire to be able to show off to fellow keyboard enthusiasts, trying to create something unique, wanting a fun hobby, and simply because it is pretty.

No company will ever be able to create a keyboard that will be perfect for everyone. Everyone's needs and tastes are so unique that it's just not possible. And their preference of what to type on can change over time.

Most of us have keyboards, yet many of us take them for granted. They're unique, they change over time, and what we like the sound of develops and evolves. There is a lot more to think about with keyboards than it first appears.

Artisan Keycaps

THIS IS WHERE things start to get into the realms of "just because we can." Artisan keycaps are the next level of craziness. As you can see, these can be anything you imagine. Do you have two cats and love the colors white and orange? No problem, commission Esquimo Keycaps to make custom kitty caps and slap them onto your board. Sure, you just lost $100, but you feel happy and you have something that no one else in the world has.

Alternatively, do you want to encapsulate the horrible fidget-spinner trend on your keyboard? No problem, Hammer has these for $30. These unique, handmade keycaps have no other use than to look pretty and ensure that you have no money left to get you into trouble. We know this. We understand they're a waste of money. We just need more. More!

TECH PORN

PERFORMANCE GEAR LAID BARE

1 TOWER POWER

The LT100 "starter kit" that we've got here consists of two towers, each with 46 addressable LEDs. The light-diffusing plastic cover on the front of each tower ensures a soft glow, unlike the harsh brightness of some other RGB accessories. They also include a clip-on bracket that can transform one tower into a headset stand.

2 KEEPING TRACK

The Nexus can be used for a wide variety of shortcuts and information readouts, but our favorite is probably the system-monitoring function. With this, the slender display can show component temperatures, fan speeds, and resource allocation in real time—perfect for keeping an eye on your system while overclocking or benchmarking.

Corsair iCue Suite

CORSAIR'S ICUE SOFTWARE has been on the block for a while now, and it's certainly one of the better pieces of RGB-control software out there. They all have their issues, whether your beef is with Razer's Synapse, Gigabyte's RGB Fusion, or MSI's Mystic Light. But iCue functions well and enables you to easily synchronize the lighting effects on your Corsair products, so a transition towards direct hardware support is hardly surprising.

We've got several pieces on display for Tech Porn this issue, but most eye-catching is the LT100 Smart Lighting Towers. These twin spires are designed to sit either side of your screen (or wherever else you'd care to mount them) and expand upon any existing lighting effects you have set up. They're impressively bright, and come pre-loaded with a ton of animated effects—or, if you're so inclined, they can dynamically synchronize to games, videos, or music.

The LT100 towers are pretty great, but they're mostly an aesthetic addition. For more control over your gaming experience, there's the iCue Nexus, a "companion touch screen' that clips onto the top of a compatible Corsair keyboard. The Nexus display is fully customizable within Corsair's iCue software; you can select up to six programmable "buttons" on-screen at once, editing the fonts, icons, and color schemes.

These virtual hotkeys can be used for all manner of quick shortcuts, whether it's instantly adjusting the lighting preset of your setup or muting in-game audio so you can better hear your chat. It's remarkably easy to set up in the iCue software menu, too. **–CHRISTIAN GUYTON**

3 LOW PROFILE

The Corsair K70 RGB MK2 Low Profile we're using here to demonstrate the Nexus is a sleek little number, bringing the trusted performance of Cherry MX switches to a slimmer, lighter keyboard. The iCue Nexus simply snaps on top and plugs in via a short USB cable—no tools required.

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PC GAMER

HOW TO

STEP-BY-STEP GUIDES TO IMPROVING YOUR PC

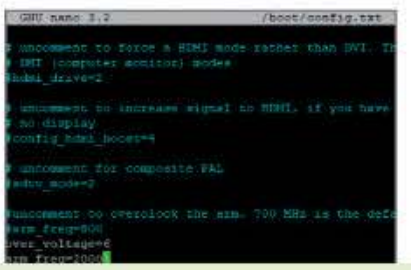
TIP OF THE MONTH

CHECK OUT MODES IN RYZEN MASTER

If you're running an AMD processor (specifically a Ryzen or Threadripper, not Athlon), you should be using Ryzen Master. It's a powerful tool for automatic overclocking, making the process of squeezing extra performance out of your CPU easier and gentler on the silicon. Even better, it comes equipped with Game Mode and Creator Mode. Depending on your usage, this is the simplest, quickest way to boost your PC's performance.

MAKE – USE – CREATE

52
Create stop-motion animation with a Raspberry Pi



54
Hack Google Stadia: Stream gaming onto a Pi

60
We put together a new testing machine

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CHRISTIAN GUYTON
STAFF WRITER

MOVE ON UP

This month, I'm moving house. Well, to be more accurate, I'm trying to move into a house, and out of a tiny apartment. Working from home is all well and good, but when you don't have a home office (or a workbench, or good internet, or storage space...) it's quite the struggle. Add in nasty neighbors and a constantly busy road, and you've got a perfect storm stuffed in a cramped space.

House-hunting is a tricky business, but I have to hand it to the software developers; seeing what properties are available nearby has never been easier. It keeps me from wasting time on homes that won't work for me. If I find a promising place, the first thing I do is scroll down to check internet speeds. 1.7Mb/s? Pass.

Satellite maps and 360-degree street views make checking out an area without leaving my couch a breeze. Even though I'm immersed in the tech world, it still amazes me how much information I have at my fingertips. The tiny rectangle in my pocket keeps me updated when new properties become available, and buzzes with alerts from real estate brokers who think they've got the perfect place for me.

Of course, finding that place is easier said than done. Hopefully by the time you read this, I'll be in a bigger abode, with a well-equipped study—or at least, not seated at my dinner table.

↘ submit your How To project idea to: comments@maximumpc.com

IFIXIT presents:

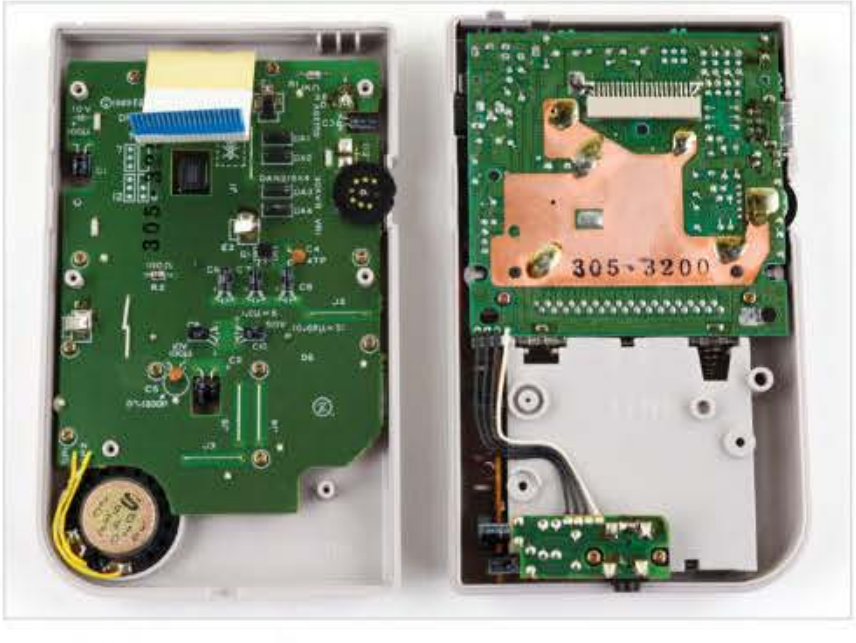
AUTOPSY

THIS MONTH WE DISSECT...

Nintendo

About iFixit

iFixit is a global community of tinkerers dedicated to helping people fix things through free online repair manuals and teardowns. iFixit believes that everyone has the right to maintain and repair their own products. To learn more, visit www.ifixit.com.



It ain't very pretty, but this silicon kickstarted a new era of handheld gaming.

The Nintendo Game Boy was initially released in Japan on April 21, 1989, followed by a launch in North America three months later on July 31. This would be the start of a handheld gaming revolution.

Game Boy

BACKGROUND

The Nintendo Game Boy was originally released in 1989. And while it wasn't the first handheld game console to hit the market, it popularized the category and kickstarted the portable gaming industry. Let's take a look!

MAJOR TECH SPECS

- Sharp LR35902 4.19 MHz CPU
- LSI Logic LH5264N4T 8KB VRAM
- 2.6" 160 x 144 LCD display
- Sharp IR3R40 amplifier

KEY FINDINGS

- Denoted by model number DMG-01 (which stands for Dot Matrix Game), the Game Boy can be powered by either four AA batteries or an AC power adapter, the latter of which has, quite unsurprisingly, disappeared somewhere into the clutter abyss.
- Despite the one model number, the Game Boy came in a handful of different models over the years, with subtle differences to the circuitry. If you're wondering, the 1-800 number on the back of the casing does still call Nintendo's support line, just in case you ever need some help with your retro handheld.
- The case is held together by six tri-point Y1 screws. Even back in 1989, Nintendo thought traditional screws might be too easy for us tinkerers. Fortunately, our Mako Driver kit comes with the necessary bit.
- Nintendo was at least nice enough to include an indentation for our driver to nicely fit into in the battery compartment. We slowly separate the two halves of the outer shell to reveal a ribbon cable booby trap! Luckily, this ribbon cable is more difficult to damage than the ones in newer devices.
- A firm grab and pull of the ribbon cable is all that stands between complete front and back separation. Once we're inside, it's all standard Phillips #1 screws from here on out. The display's circuit board is held down with 10 of them.
- Using one of our own iFixit opening tools, we slowly start prying from the top, as the display and circuit board are ever so slightly glued to the case. The LCD display is attached to the circuit board with clips and a couple of screws. Unfortunately, the display's cable is soldered to the board, as are the speaker's two wires.
- The circuit boards inside the rear case are much easier to remove, with only four screws and no adhesive holding it down! The main board, power board, and jack board are connected together and come out all at once. As with the display and speaker wires, the headphone jack and other ports are all soldered to the boards.
- And that's it! We hope you enjoyed this trip down memory lane. Now if you'll excuse us, we're going to put this thing back together and enjoy some *Super Mario Land 2*.
- Repairability Score: 3 out of 10 (10 is easiest to repair). The Game Boy only uses Phillips screws inside the casing, but even the exterior tri-point screws are easy to deal with nowadays. Only a small amount of (replaceable) glue was found inside. Many parts and cables are soldered directly to the boards, making individual replacements difficult. Soldering equipment and knowledge is required for most component repairs, such as the headphone jack, speaker, and display. AA batteries are obviously easy to replace.

Create Stop-motion Animation with a Pi

YOU'LL NEED THIS

RASPBERRY PI 4 OR 3B+

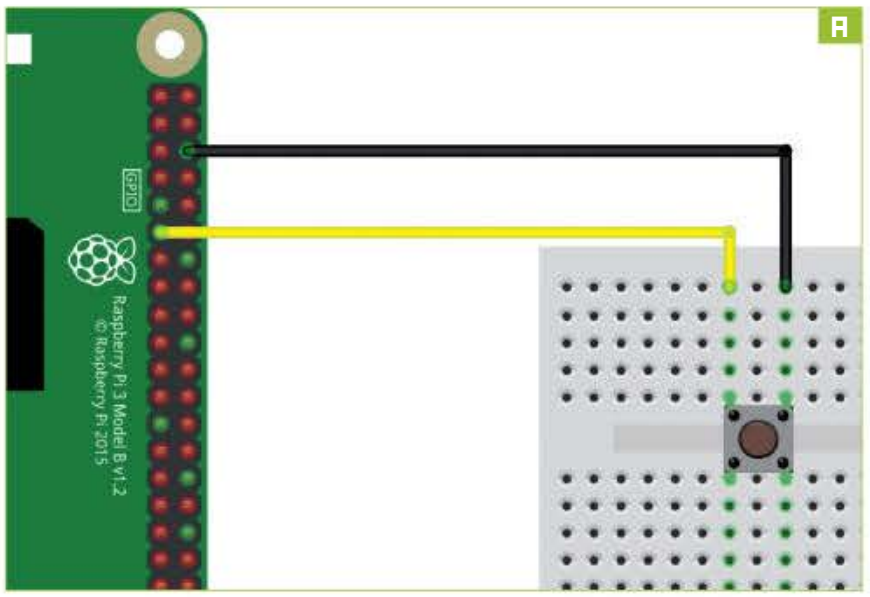
RASPBERRY PI CAMERA
Preferably the High Quality camera.

RASPBIAN
The Pi's Debian-based operating system.

WALLACE AND GROMIT, THE EVIL SKELETONS created by Ray Harryhausen... these are all famous examples of an animation technique called stop-motion, which uses individual images posed by an animator so that, when run as a sequence, the subject appears to move. Traditionally this takes many hours or days of painstaking work. But using the power of the Raspberry Pi and its camera, we can make our own movie studio. In this tutorial we will make a short animation using a LEGO model, all filmed using Python and the Raspberry Pi.

The button that triggers our camera is a push button inserted into a breadboard. This is then connected to GPIO pin 17, and GND.

The Raspberry Pi Camera now comes in many different variations, ranging from the V1 camera and its fixed focus lens, to the latest High Quality Camera and its interchangeable lenses. They all connect to the camera port of the Raspberry Pi, located just behind the Ethernet and USB ports. Open the camera port by gently lifting the plastic lock upwards, and then insert the ribbon connector, with the blue tab facing the USB and Ethernet ports. Close the lock on the connector and give it a gentle pull to make sure it's in place, and you're ready to go. **–LES POUNDER**



1 TEST THE CAMERA

Power up the Raspberry Pi and then go to "Preferences→Raspberry Pi Configuration." Under the Interfaces tab click the "Enable" button for the camera. Then click "OK" and reboot the Pi.

›› With the Pi rebooted we can now test the camera. Open a Terminal and type the following command to take a quick picture:

```
$ raspistill -o test.jpg
```

›› A preview window should appear, giving us five seconds to frame the shot before the image is saved to disk as test.jpg. We can take a look at the image using the file manager. If there are any issues, go back and check that the camera is properly connected and that the camera interface is enabled.

2 CODING THE PROJECT

The code for this project is written in Python, and the default editor for Python is now Thonny, found in the Programming menu. The first three lines of code are where we import modules of pre-written code. This enables our project to use the GPIO to create a push-button trigger, use the camera and prevents our code from exiting:

```
from gpiozero import Button
from picamera import PiCamera
from signal import pause
```

›› Next, we can create a global variable—one that can be used outside and inside a function. We need this to create a variable called `order`, which will be used to number the images as we press the button:

```
global order
```

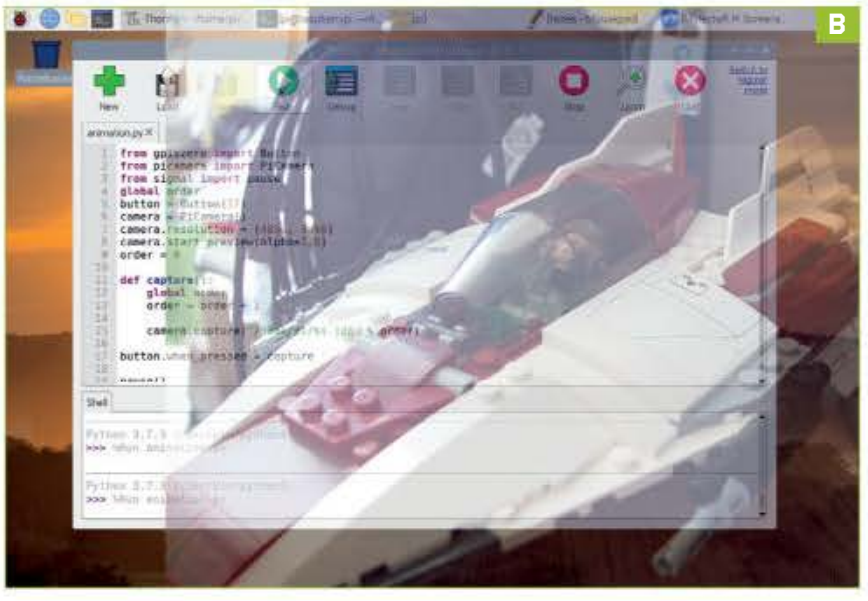
›› The next two lines create objects that enable our code to interact [**Image A**]: first, with our push button connected to GPIO 17, and second, with the Pi camera:

```
button = Button(17)
camera = PiCamera()
```

›› To set the image resolution, call the camera object and then specify a resolution as a tuple. In our project we used the High Quality Camera, and at the time of writing this has a small problem with images smaller than the maximum resolution, so change this to match your requirements, say (1024, 768). But HQ camera users, please set this to (4056, 3040) until the issue is fixed.

```
camera.resolution = (4056, 3040)
```

›› The last two lines in this section of code will start a preview window, giving us the chance to see what the



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camera sees, and enabling us to frame the shot accordingly. We alter the transparency of the preview window using `alpha` and set this to 128, which is approximately 50 per cent transparency. We do this so that we can still see the Thonny application window, in case there are any errors [**Image B**]. The last line sets our `order` variable to 0, which will enable our image filenames to start fresh each time the code is run.

```
camera.start_preview(alpha=128)
order = 0
```

3 MAKE A SCENE

Next, we can create a function called `capture`. This is the code that's run each time the button is pressed. Functions are given a name, called "defining a function," and any code that's run when the function is called is indented to show that. Our function uses the global variable `order` and we update the value of that variable by incrementing the value by 1 each time the button is pressed. Then we call the `camera.capture` to take the picture. The filename of the image is set to /home/pi, and `%` places the contents of the `order` variable as a string at this point in the text:

```
def capture():
    global order
    order = order + 1
    camera.capture('/home/pi/%s.jpg' % order)
```

» The final lines of Python code are our button trigger, which when pressed will launch the function that we have just created. Then the code will pause, preventing the code from exiting, and forcing it to wait for more button presses:

```
button.when_pressed = capture
pause()
```

» Save the code as animation.py and click "Run" to start. You should see a ghostly image appear over the top of the desktop. This is a live preview that we can use to frame our shots. Now is the time to get some LEGO bricks, toy cars, or modelling clay and make a scene [**Image C**]. When ready, press the push button to take a picture, then move the items a little, take another picture and repeat until you're done. To stop the code, press the "Stop" button in Thonny.

4 MAGIC MARKINGS

We should now have a series of images in /home/pi that are numbered from 1. Create a new folder called animation and move the images to there. To convert these JPEG images into an animated GIF, we need to install some software. In a Terminal type the following to install ImageMagick, which is a great tool to manipulate images from the Terminal:

```
$ sudo apt install imagemagick
```

C

RASPBERRY PI HIGH QUALITY CAMERA

The new Raspberry Pi High Quality Camera is fantastic. It may cost much more than the standard camera, but it uses interchangeable lenses (bought separately). We can also use old C and CS-mount lenses, or other lenses via adaptors. A proper aluminum screw mount provides a solid fitting to secure our camera to a tripod. The new camera connects to all models of Pi with a camera connector, including later models of the Pi Zero via an adapter cable. It can be controlled using Python, as we did in this tutorial, and can be used directly via the `raspistill` and `raspivid` commands in the Terminal.

But what makes the latest camera so different to those before it is that there's so much manual control. We can alter the focus and light levels to get the best shot. We can use the camera as a webcam for video calls to friends and family. The new camera starts at $50 with no lens, and a 6mm wide-angle lens is around $25. A 16mm telephoto lens costs around $50. Both of these lenses provide crisp optics for the Sony IMX477R 12.3 megapixel sensor.

» In the Terminal, navigate to the animation folder.

```
$ cd animation
```

Next, we can use ImageMagick to convert the images into an animated GIF. We use the `convert` command and set a delay to 1/10th of a second (100ms). The image will infinitely loop if we set the number of loops to 0. Then we can tell the command to use all of the JPEGs that are in the folder. The output file can be called something like animation.gif:

```
$ convert -delay 10 -loop 0 *.jpg animation.gif
```

» The process will take some time, but when complete, open a web browser and drop the animation.gif file from the file manager onto the browser. The image will load and you'll see the animation play in the browser. Don't stop there—build a bigger project with your materials and figures, and bring it to life, too!

Hack Stadia: Stream Gaming onto the Pi

YOU'LL NEED THIS

PC OR LAPTOP
(Or custom game server) running on the same network as the Raspberry Pi.

GAME CONTROLLER
Or two.

DESPITE ITS SIZE AND LOW POWER, the Raspberry Pi has proven to be a useful addition to any game-streaming setup. While it won't run modern games, it can stream them from a PC with Steam or Parsec. All you need is the PC or laptop (or custom game server) running on the same network as the Raspberry Pi, and a game controller or two connected to it.

The same is true with Google Stadia. You might have heard about Google's game-streaming platform, which pre-launched in November 2019 ahead of full launch in 2020. It enables the streaming of AAA games to your desktop PC computer, potentially with just a subscription. Want to stream games to your TV? You can, using a Google Chromecast Ultra and dedicated wireless game controller (see boxout).

But all of the above can be handled using just a Raspberry Pi. With the basic Stadia tier, you could be streaming a newly purchased video game to your TV through your Raspberry Pi. Yet while setup is straightforward, the results aren't always perfect. The Raspberry Pi 4 is just about able to deal with streaming Stadia games, but there is some lag. Your mileage may vary on this; it will depend on what games you're playing as much as the natural limitations of the Raspberry Pi.

The fact that this works at all is amazing. Making Stadia available on as many platforms as possible via apps and the Chrome browser appears to be a key distribution strategy for Google, so there's a chance that future updates might improve Pi streaming. That said, don't expect 4K streaming. To improve the chances of everything working, you'll need a Raspberry Pi 4 4GB, hooked up to your router with an Ethernet cable. **–CHRISTIAN CAWLEY**

A

```
GNU nano 3.2                  /boot/config.txt                  Modifi

# uncomment to force a HDMI mode rather than DVI. This can make audio work in
# DMT (computer monitor) modes
#hdmi_drive=2

# uncomment to increase signal to HDMI, if you have interference, blanking, or
# no display
#config_hdmi_boost=4

# uncomment for composite PAL
#sdtv_mode=2

#uncomment to overclock the arm. 700 MHz is the default.
#arm_freq=800
over_voltage=6
arm_freq=2000

# Uncomment some or all of these to enable the optional hardware interfaces
#dtparam=i2c_arm=on
#dtparam=i2s=on

^G Get Help  ^O Write Out  ^W Where Is  ^K Cut Text  ^J Justify   ^C Cur Pos
^X Exit      ^R Read File  ^\ Replace   ^U Uncut Text^T To Spell  ^_ Go To Line
```

1 PREP YOUR PI

To get anywhere close to lag-free input on Stadia with a Raspberry Pi 4, start with a lightweight distro. For testing we used Raspbian Buster Lite with the Xfce desktop. Start by opening a terminal and updating and installing necessary upgrades.

```
sudo apt update && sudo apt dist-upgrade
```

Reboot with:

```
sudo reboot
```

When the Pi restarts, install X.Org Server and Xfce:

```
sudo apt install xserver-xorg
sudo apt install xfce4 xfce4-terminal
```

›› Next, be sure to connect the Pi to your router using an Ethernet cable rather than relying on Wi-Fi. To persuade the Raspberry Pi to run at its fastest, you'll need to overclock it [Image A]. This has some downsides: While the Pi will run faster, performance will become less reliable. Certain stability issues can occur, such as SD card corruption, or unannounced system crashes.

›› Overclocking the Raspberry Pi 4 is slightly different to older versions. Start by removing the Pi from its case and placing it in a vertical position. If you don't have a fan attached to the SoC, this is the best way to encourage cooling. A couple of pieces of LEGO can help with this arrangement; you might be able to balance the Pi in one half of the case. With that arranged, it's time to start stepping up the Pi's voltage and clock speed. Open config.txt:

```
sudo nano /boot/config.txt
```

Find the section labelled "#uncomment to overclock the arm. 700 MHz is the default." Add the following to step up the speed:

```
over_voltage=2
arm_freq=1750
```

Hit Ctrl+X to save and exit, then reboot again. If the Pi boots successfully, return to config.txt and tweak the settings again:

```
over_voltage=6
arm_freq=2000
```

›› This should be enough for running Stadia on Chromium. You can overclock to `arm_freq=2147` and add `gpu_freq=750`, but this is pushing the boundaries of stability without a high-end cooling solution.

›› Remember, if the Pi gets stuck in a reboot loop or fails to start correctly, you can fix it by changing config.txt. Revert to `arm_freq=800` and remove the `over_voltage` setting, then save, exit, and reboot. Failing that, you'll need to re-image your SD card.

2 STREAMING WITH CHROMIUM

You are probably aware that Chromium offers the best browsing experience on the Raspberry

© FOCUS HOME INTERACTIVE, RASPBERRY PI FOUNDATION

Pi. It streams Netflix and other services, and is the only way to access Stadia. This is the same on other platforms, where Google Chrome (based on Chromium) is the only option to play games through Stadia.

» With the board operating at top speed, it's time to install or update Chromium:

```
sudo apt install chromium-browser --yes
```

» Reboot the Pi, then open the browser and visit https://stadia.google.com. If you don't already possess a Google account, set one up and then sign up to Stadia, making sure to avoid any unexpected bills when the trial period ends by setting a reminder. If you already have Stadia, sign in.

3 CONFIGURE A GAME CONTROLLER

To play games on Stadia you need a game controller that can be routed via Chromium. The Stadia controllers are the best option here [**Image B**], connected via USB-C cable. While they usually connect via Wi-Fi to the remote game server, this won't sync correctly with browser access on any platform.

» Other controllers are supported by Stadia, including the Xbox One controller and the PS4 controller. Again, you'll need to use them in cabled mode rather than over Bluetooth. Some third-party generic USB controllers will also work, but ensure that they have two thumb sticks, D-Pad and triggers. Most USB controllers should plug in and play on the Raspberry Pi. Drivers for popular devices are included in the kernel.

» When you're ready, select a game on the Stadia page and click the play button to start. You'll notice right away that there's some lag. This is inescapable but is less important with some games. We've found that some games perform better than others. So, avoid high-octane thrills like *Thumper* or *Samurai Shodown*, in favor of puzzles or strategy titles like Spitlings or slower games *Farming Simulator 19* [**Image C**]. Curiously, *Destiny 2* is reported to play well with the Raspberry Pi 4.

4 IMPROVING PI-BASED STADIA

Following Steam Link and Parsec, this is just another way to play PC and console-standard games on the modest Raspberry Pi. While lag is a problem, there's a feeling that things might improve, making the Raspberry Pi a competent alternative to a Chromecast Ultra as a dedicated Stadia device.

» So, what can you do to improve performance? One option is to try a different OS. ChromiumOS for the Raspberry Pi is one option, but another is Android. Several Android builds are available for the Raspberry Pi 4, although Konstakang's LineageOS 16 (based on Android 9) is considered by the developer to be currently unsuitable for media or gaming at this stage. It does, however, offer a tempting option for future Android use on the Pi 4.

» As with many Pi projects, your mileage may vary. At worst, you'll get a buzz of satisfaction from accessing Stadia on your Raspberry Pi; at best, you can run a virtual farm.

STADIA: IT'S BETTER THAN EXPECTED

You might be reading this thinking, "Google Stadia—isn't that the tinhorn one with no games?" and you'd be partially correct. While it's true that Google Stadia doesn't yet boast a games library to challenge Xbox One or PS4, it's far from tinhorn. A few features (such as sharing screenshots and videos) took a while to mature, but Google Stadia is a game-streaming platform that's worth some serious consideration.

With a relatively modest internet connection you can enjoy perfect streaming at standard resolution. It really is as if the game is streaming on a console on your home, rather than on a remote server somewhere. Ethernet delivers the best results to the streaming device (whether a Chromecast Ultra, Android device, desktop PC or Raspberry Pi), so all you need to do is be sure you have a suitable controller to hand.

Stadia features two tiers, although neither is perfect. The Premiere Edition (which replaces the pre-launch Founders Edition) is $99.99. This includes a game controller and Chromecast Ultra, 4K streaming, and free games monthly, but you'll need to pay a subscription. The second tier, Pro, comes without the hardware, costs $9.99 a month with a two-month trial, and lets you buy games as and when you want.

Do More With Your WordPress Website

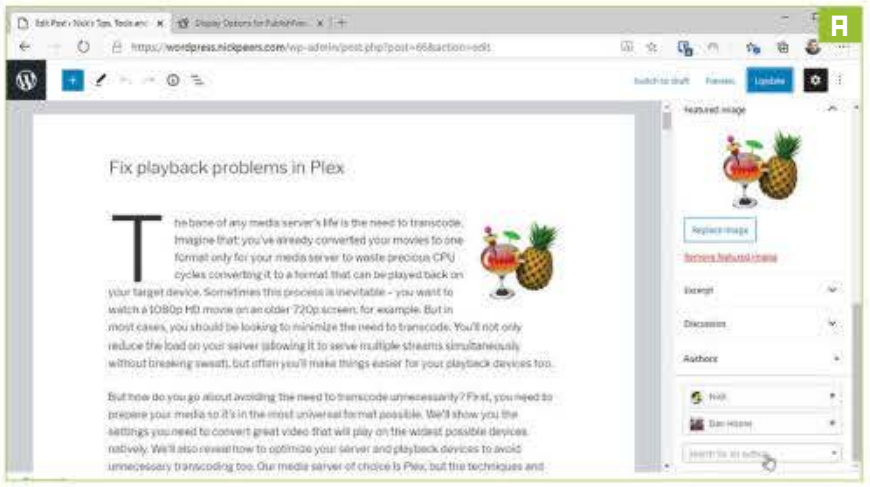
YOU'LL NEED THIS

WORDPRESS SERVER
Any reputable web host will do, or you can host it yourself on your own server.

YOUR WORDPRESS WEBSITE is up, running, secure, backed up and looking exactly as you wanted. But you've barely scratched the surface of what you can do with a WordPress site. To finish off this four-part series we'll look at several ways in which you can make better use of it, from setting up contributors to help you fashion content, to finding ways to tweak your site's settings to maximize performance and make things better for your site's visitors.

There's also time to explore how to set up a commenting system, plus benchmark—and improve—the visibility of your website with search engines, helping you drive more traffic to your pages. We'll even take a look at three types of plugin to add money-making capabilities to your site, from an online store to a subscription-based paywall to lock certain content away.

Once you've explored all these avenues, what next? It goes without saying that you should bookmark WordPress's own support pages (https://wordpress.org/support)—a mixture of online documentation and community support through forums—but also take a look at CreativeBloq's curated list of 40 brilliant WordPress tutorials (http://bit.ly/MPCcreativebloq) to give you more ideas, tips, and tricks to follow. **–NICK PEERS**



A

1 MULTI-USER WEBSITES

Keeping a website regularly updated with fresh content on your own can be hard, but WordPress makes it easy to collaborate with others thanks to its support for multi-user setups. Roll your mouse over "Users" in the WordPress dashboard's left-hand menu and choose "Add New." Fill in the details as requested to create a new user—the only option you need to think carefully about is their role: Avoid making anyone other than yourself "Administrator."

›› Give trusted users "Editor" access, which allows them to publish and manage posts across your site, including those written by others. Choose "Author" to allow a user to publish and manage their own posts only, or "Contributor" to allow them to write and edit their own posts while you retain control over publishing them.

›› WordPress automatically generates a strong password for the new user—be sure to record this and share it securely with your new site contributor so that they can log in.

2 SHARE AUTHOR CREDITS

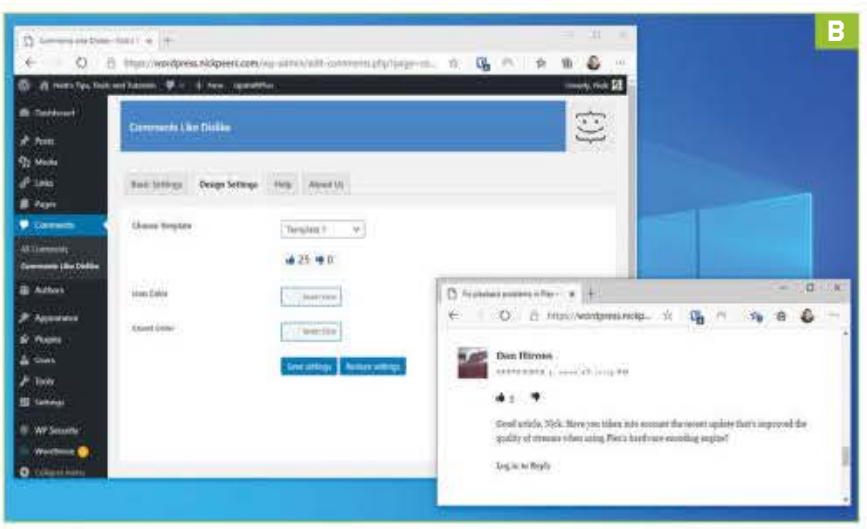
By default, whoever creates a new post is deemed its author. You can change this via a post's "Quick Edit" menu or via the "Status & visibility" section of a post's "Document" properties, but this limits you to one author. If you want to credit two or more users within a post, you will need to use a plugin—our recommendation is PublishPress Authors (http://bit.ly/MPCwordpressauthors), which is very simple to use and set up.

›› Once activated, configure it via its own "Authors" icon in the WordPress dashboard. Select "Authors" to verify that all your users are listed; if not, type their name into the "Mapped User" dropdown list and the plugin should pick them up. Once done, choose "Authors → Settings → Display tab" to tweak how the authors are displayed within posts. When you next edit a post, you'll find a new, dedicated "Authors" section in the "Documents" properties [**Image A**], where you can type the name of your chosen co-author (or co-authors) to add their credit.

3 MANAGE COMMENTS

User feedback is a valuable part of any blog, but simply allowing anonymous comments across all your site is a recipe for trouble, with spammers and trolls ruining the experience for everyone else.

›› Visit "Settings → Discussion" and you'll see that WordPress offers various settings for controlling feedback, with some minimal protections already in place: Commentators must fill out their name and email before posting, while all comments posted by new posters are held for moderation via the "Comments" section of the dashboard.



B

© WORDPRESS

» To tighten things further, you can manually specify banned keywords (including URLs, email addresses, and IP addresses) that automatically prevent a comment from being published. You can also remove the ability to comment on individual posts and pages via their own properties page.

» You can limit comments to registered users of your site by ticking "Users must be registered and logged in to comment." If you go down this route, visit "Settings → General" and tick "Anyone can register," leaving the new user default role set to "Subscriber." Be sure to also add the Meta widget via "Appearance → Widgets" to make the "Register" option more visible.

» If you want to explore different ways of registering users, try the Easy Registration Forms (http://bit.ly/MPCwordpresseasy) plugin. Another plugin worth adding is the Comments Like/Dislike (http://bit.ly/MPCwordpresscomments) to encourage quickfire thumbs-up and thumbs-down reactions to feedback from site visitors—once activated, set it up via "Comments → Comments Like Dislike" on the WP dashboard [**Image B**].

4 MAKE PAGES MORE VISIBLE

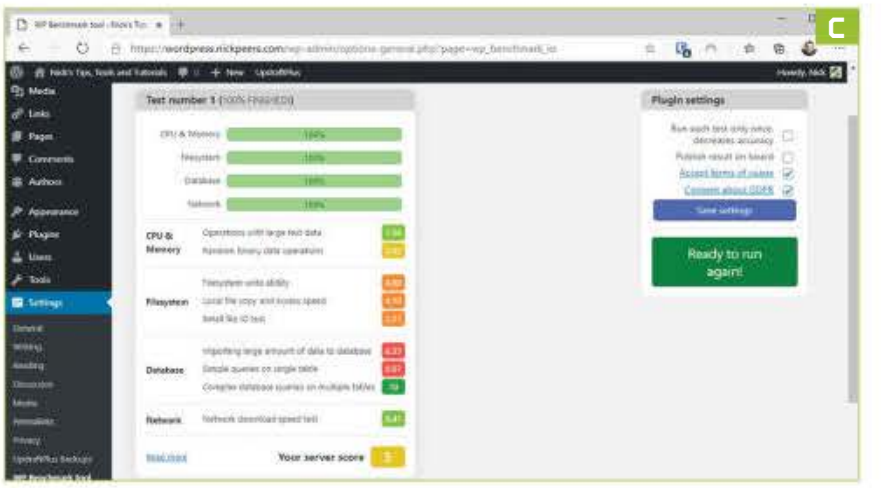
The key to increasing footfall to your website lies in getting it noticed on search engines, and that involves a combination of Google Analytics for measuring your site's popularity, and a good SEO (Search Engine Optimization) keyword strategy, which reveals the words and phrases that are likely to make your site more visible.

» Install the free versions of the MonsterInsights plugin (www.monsterinsights.com) to connect your site to Google Analytics, and the Yoast SEO plugin (http://bit.ly/MPCyoastSEO) to help score some quick and easy improvements. Upgrade to paid-for plans if you need additional refinements.

5 TWEAK PERMALINK SETTINGS

Another quick way to increase the visibility of your site is to improve the readability of your permalinks—these are the links created to allow you to share reader-friendly URLs of specific posts and pages. You can manually edit a post's permalink via the URL slug field under "Quick Edit" or under "Permalink" on your document's properties during editing, but you can also choose the permalink format for all posts to add additional information.

» To do this, navigate your way to "Settings → Permalinks." Choose "Custom Structure" and type /%category%/%postname%/ into the box to not only make your permalink more readable, but render the page more SEO-friendly too.



C

6 IMPROVE SITE PERFORMANCE

If your site seems slow to load, or responds sluggishly despite performing well at first installation, there are a couple of things you can do to improve matters instantly. First, deactivate and remove any unused plugins, and consider rationing how many you have installed at any one time. Also, check your theme—is it similarly bloated? If so, try switching to a lightweight alternative.

» You'll find plenty of plugins offering to turbo-charge various aspects of your site—if you're looking for maximum return on minimum effort, then invest $49 per year in the WP Rocket (https://wp-rocket.me) plugin. But before doing that, try the free WP-Optimize (http://bit.ly/MPCwordpressoptimize) plugin instead.

» WP-Optimize focuses on three areas. First, it ensures that your underlying databases are tidied up and streamlined—this will have the biggest effect on more established WP sites for obvious reasons. Second, the plugin can compress all your site's images quickly, with an option to restore the originals at any point if you don't like the result. You can bulk-compress files up to 5MB in size (64MB for one-off files), plus have files automatically compressed when they're uploaded. And third, it utilizes several page-caching tricks to help reduce loading times further.

» Finally, if you're worried that your host may not have enough oomph to power your website, install the WordPress Hosting Benchmark Tool (http://bit.ly/MPCwordpressbenchmark) to perform a series of tests to see whether or not an upgrade may be required [**Image C**].

RUN A BUSINESS WITH WORDPRESS

WordPress can do far more than just serve webpages—if you would like to sell goods or services online, then install the free version of the WooCommerce plugin (https://woocommerce.com), which has all the functionality you need to add an online shop to your site. Pair it with a free Woocommerce-friendly theme such as Boutique, Storefront, or Deli, and you can be up and running in a short period for no outlay.

You can also use WordPress to manage an online booking system. If you're not charging for bookings, consider Easy Appointments (http://bit.ly/MPCwordpressappts). Bookly (http://bit.ly/MPCbookly) also has a free tier that you can use, but you'll need to pay for a Pro license ($89, one-time cost) to accept paid bookings, install Bookly add-ons, and work with unlimited services and staff members. A cheaper alternative that's worth considering is the Booked plugin ($49, https://getbooked.io).

If you'd like to build a members-only website in WordPress involving some form of subscription-based paywall, then try S2Member (https://s2member.com), which offers a free tier that supports PayPal as a payment provider. The Pro version adds more features and payment-provider support for a one-time fee of $89 that covers a single site.

One final tip: If you're planning to run business services, make sure you choose a premium hosting package—these plugins are extremely demanding, and cheaper hosting plans will struggle to cope.

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Find The Perfect Black Friday Deal

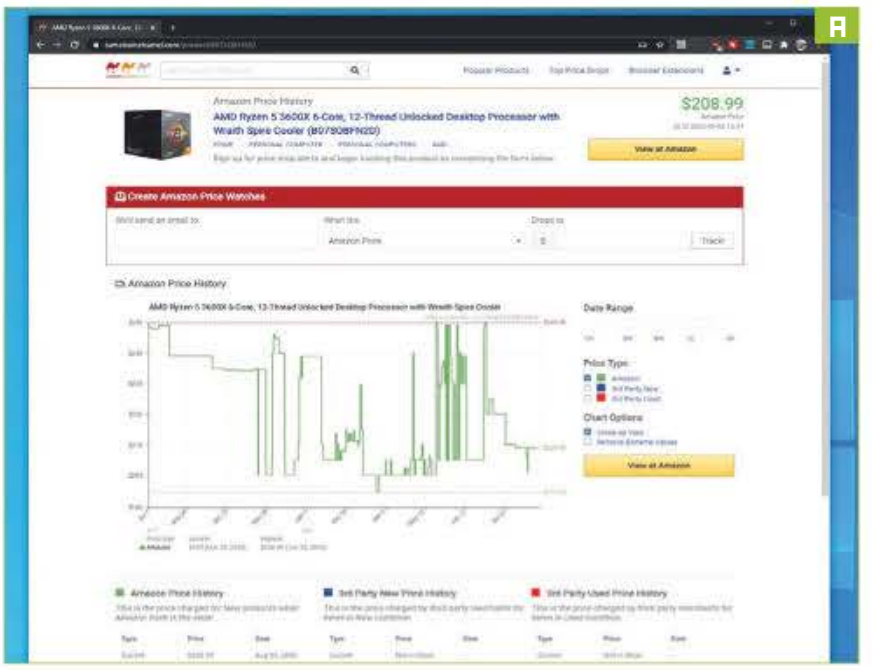
YOU'LL NEED THIS

A WEB BROWSER
Some deal-listing sites, and your favorite etailers.

CAN NOVEMBER really be rolling round again? Yup, and that can only mean one thing. No, not the election, but Black Friday, none other than the best day of the year to get great deals on PC kit. But how, exactly, do you get the best deals, and how does it all work?

The easy answer is to log on to the websites of **MPC**'s sister titles, including www.techradar.com, www.tomshardware.com and www.pcgamer.com and allow them to do the heavy lifting for you, all neatly categorized and simple to select. But that leaves the question of how those websites themselves go about selecting the best deals.

You're in luck, for your erstwhile correspondent has been a member of the crack deal team on several occasions. Here's your behind-the-scenes peak at how it all works, and what that means for you and getting the best deals. –**JEREMY LAIRD**



A

1 MANUAL WORK AND DEAL-MAKING

The first and perhaps most surprising fact about Black Friday deals is that it's all essentially done manually. In an age where AI is all the rage, you might think that choosing deals would lend itself nicely to an algorithm or three. Nope. As in many other disciplines, the scope of AI is exaggerated, and it's humans that add the value. Actually, the fact that deal listings aren't done by AI says a lot about the true maturity of that so-called technology. But that's a story for another day.

›› The next surprising fact is that it's relatively laborious and depends significantly on existing knowledge, and not just using the right search tools. Many leading etailers, including Amazon, the 800-pound gorilla of online outlets, don't make it entirely easy to find deals in specific categories. Yes, filters can be applied, but they don't always work reliably or as expected. So a heap of manual trawling goes into the mix.

›› What you probably won't be surprised to learn about, if you didn't already know, is the kickback for websites recommending deals, otherwise known as affiliate commission. In short, the website recommending the deal gets a small cut if you link through and buy. If that sounds at all rotten, it's not. Serious players in deal listings have arrangements with all the major etailers, thus the interests of the websites listing deals are perfectly aligned with yours. The better the deal they point you at, the more likely you are to buy and earn them a little cut.

2 PRICING AND EXPERIENCE

But what of pricing, surely the most critical factor in any deal worth the name? Pretty much all participating etailers play it fairly fast and loose with their definition of a deal. In other words, the advertized saving isn't always what it seems. It may not be indexed against the price just before Black Friday, but compared to another earlier and higher price that was only instituted relatively briefly and isn't terribly representative of a given product's typical cost. Overcoming that involves a combination of experience and a few online tools.

›› For Amazon there's a handy tool for tracking any deal against its historical price. Simply load up https://camelcamelcamel.com [**Image A**] and drop the product's Amazon URL into the search field and, boom, you'll see if the deal price is actually any good. There are more generic tools, like https://pcpartpicker.com and Google Shopping, which can be very useful. The problem, however, can be timeliness. Some of the best deals are gone in a flash. That's where experience counts. The ability to quickly recognize a good deal without the need to cross-reference historical pricing saves critical time.

3 BUYER'S GUIDE

As for what you, the actual deal-shopper, should do, we'd recommend combining the best of **MPC**'s sister websites with a little manual searching of your own. By using the likes of techradar.com, tomshardware.com and pcgamer.com, you're benefitting from a dedicated team of deal-hunters who can cover far more of the web than you could on your own.

›› The catch is that some of the best deals appear and disappear so fast that solely relying on deals fed to you by third parties could mean missing out. So it's a good idea to have the relevant sections of several of the top etailers saved as browser favorites for easy access. Also consider signing up for various early-access memberships, such as Amazon Prime.

DEAL-LISTING SITES:
Techradar.com
Tomshardware.com
PCgamer.com

TOP BLACK FRIDAY ETAILERS:
Amazon.com
Newegg.com
Bestbuy.com
Walmart.com
BHphotovideo.com
eBay.com

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BUILD IT

CHRISTIAN GUYTON, STAFF WRITER

Testing, Testing

In need of a new test bed? We are, so we're putting together a new system for review purposes

LENGTH OF TIME: **1-2 HOURS**

LEVEL OF DIFFICULTY: **EASY**

THE CONCEPT

SOMETIMES we need to test stuff. In fact, sometimes it feels like testing makes up most of what we do here; the writing side of this business is really more of a casual hobby. One of the things that we find quite hard to test is cases, because cases are rather stupid.

No, we don't mean that—at least, not in the rude sense. Cases are "stupid" because they (with some strange exceptions) lack the intelligent technology that enables us to run programs and games, and by extension benchmarking software. We can fire up a graphics card or a laptop and run software tests on it until the cows come home, but cases don't offer us that same luxury.

Our case reviews typically involve the building of a system in said case to get a good feel for what using it is like. We can then follow this up with more hands-on testing, looking at thermals, airflow, and noise production, all to determine whether the case is worth buying or not. But what we don't have right now (thanks, COVID) is a unified system for testing these cases. That's what this build is going to be: A powerful ATX-scale PC, designed to be transplanted into other cases further down the line.

Now, we know this won't work for every single case review we do (ITX machines are right out), but it's important to have a baseline. For this build, we know we'll need a standard ATX motherboard, air cooling (useful for finding out how much noise a case can mitigate), a powerful modular power supply, and a high-end CPU for stress-testing. This should be an eminently capable system in its own right.

CASE STUDY

THE CASE OF THE DAY is MSI's MPG Sekira 500X, a bulky case with some seriously large fans. In addition to the 120mm rear fan, there are four 200mm fans pre-installed here—two in the roof, and two in the front. Only three of these are packing RGB lighting, since the fourth is hidden behind the solid black panel at the front of the case. An RGB strip divides this panel from the glass window beneath it, and it all lights up quite appealingly when it's provided with power. A single button on the front I/O allows for immediate lighting changes.

We won't be using any brand-new parts here, since we don't want to blow up the pricing of this build right away. Our GPU is a good old-fashioned GTX 1080 Founders Edition. We built this machine before Nvidia blew everyone away with the staggering RTX 3000 series announcement, so we know it looks a bit silly now. Similarly, even the i9-9900K we're using looks a little dated beside Intel's shiny new goodies. Nonetheless, these parts will serve our needs excellently.

We're using a pretty standard motherboard here—the Z390 Aorus Pro from Gigabyte. Not too many bells and whistles to be seen, just good all-around performance. Also going onto that mobo is a Corsair Force MP510 SSD with 240GB of capacity (no need to slap a massive drive in a testing build), and a Noctua NH-U12A, a dependable choice of air cooler with dual 120mm fans.

Memory will be handled by another familiar face, the Corsair Dominator Platinum RGB. This time around we've got a simple 2x8GB kit at 3,600MT/s, both sticks equipped with Corsair's custom 10-layer PCB and 12 ultra-bright, fully addressable LEDs. Finally, we're bringing a good amount of power to this build with the Ion+ 860P PSU from Fractal Design. Its 860W capacity, modular design, and 80+ Platinum efficiency certification make it a strong choice.

INGREDIENTS

PART		STREET PRICE
Case	MSI MPG Sekira 500X	$205
Motherboard	Gigabyte Z390 Aorus Pro	$190
CPU	Intel Core i9-9900K	$400
CPU Cooler	Noctua NH-U12A	$140
Memory	16GB (2x8GB) Corsair Dominator Platinum RGB DDR4-3600	$150
GPU	Nvidia GeForce GTX 1080 FE	$860
PSU	860W Fractal Design Ion+ 860P	$140
SSD	240GB Corsair Force MP510	$52
OS	Windows 10 Home 64-bit OEM	$26
Total		$2,163

1 WALLS COME DOWN

THE MPG SEKIRA 500X is a big, heavy case, with glass on three sides and five included fans, so be careful when unboxing it—it sits on flat rubber feet, which can make placing it down on a surface quite difficult. Multiple parts can be stripped away from the metal frame, but we're going to keep the initial stripdown quite simple: No need to meddle with the plastic push-pins that hold the front panel in place, as the case fans are pre-installed. The two side panels will need removing, though; these open via chunky plastic handles (admittedly useful for keeping grubby fingerprints off the tempered glass), then just lift off their hinges. Place these carefully back in the box for now. We're not using them in this build, but we'd like to draw attention to the snap-out drive cages built into the PSU shroud. They're super-easy to remove, making the Sekira 500X an excellent choice for any HDD-heavy build.

2 BOARD GAMES

UNPACKAGE YOUR MOTHERBOARD and place it carefully in a dedicated workspace. If you don't have an anti-static mat or workbench, simply place it on top of the box (remember that the plastic bag only has an anti-static coating on the inside!). Set aside the bag of accessories; you may need an M.2 screw later, but we won't need any extra SATA cables for this build.

The rear I/O shield is pre-attached to the motherboard, so there's not too much to do here. We're not using a brand-new board (long-time readers will probably recognize the Z390 Aorus Pro), but if you're buying a fresh model you'll have a black plastic cover over the CPU socket. If you're not familiar, don't worry about this: It pops off automatically when you fit the CPU. Get your tiny screwdriver ready for the next step.

3 SHIELDS DOWN

BEFORE WE INSTALL the drive, the Z390 Aorus Pro has a heat shield that needs to be removed. Since our Corsair SSD is a standard 2280 M.2 drive, we'll use the smaller slot further away from the CPU socket. Again, if you've bought a brand new motherboard the heat sinks will be pre-fitted, otherwise, you may need to fish the smaller shield out of the box and make sure you have the necessary standoff and M.2 screw.

If you do need to remove the heat shield, simply grab the aforementioned tiny screwdriver and unscrew the smaller shield—once the screw is removed, the heat sink slides easily out of its slot above the M.2 port. Set the heat sink aside for later, but don't remove the plastic cover from the sticky heat pad just yet.

4 DRIVE-THRU

IT'S TIME TO FIT our Corsair Force MP510 SSD. This is straightforward enough; plug the M.2 drive into the port and gently push it down so that it lines up properly with the silver standoff. Once you're confident that the drive is in position, remove the plastic strip from the heat shield's thermal pad and carefully slot the shield back into place before pushing it down over the drive. These sticky pads are prone to tearing, so do this carefully.

Screw the drive and heat shield down together using the provided M.2 screw, but be careful not to over-tighten it; the heat shield is more sturdy than the drive itself, and may cause it to bend. Onwards to the CPU!

7 FAN PLAN

WITH THE HEAT SINK TOWER securely in place, mount the 120mm fans on either side of the cooler. This can be fiddly, as you'll need to use the thin wire brackets to affix each fan to the tower. We won't use the "low-noise" adapters, as these fans are fairly quiet anyway and we want to know how much racket the case can mute out.

Fit the wires into the holes on the first fan, then place it up against the tower and clip the bracket over the shaped clasp on the fins. Repeat this on the other side, making sure that the two fans are aligned and facing the same direction—use the tiny arrows on the fans to check that both are directing air towards the rear I/O of the mobo.

8 RANDOM ACCESSIBILITY

OPEN UP THE CLASPS on the DIMM slots and unbox the memory. The Dominator Platinum RGB RAM is flashy as heck, but thankfully also easy to install and customize. Use slots A2 and B2 (that's the second and fourth slots from the CPU socket) for optimal memory performance. All you need to do is place each stick into the appropriate slot and push down at either end until it clicks into place.

We recommend plugging in the two PWM cables from the cooler fans before installing the memory, so you can neatly tuck them out of the way of the DIMMs. With all the clasps secured, let's move on to the next step.

5 DUE PROCESSOR

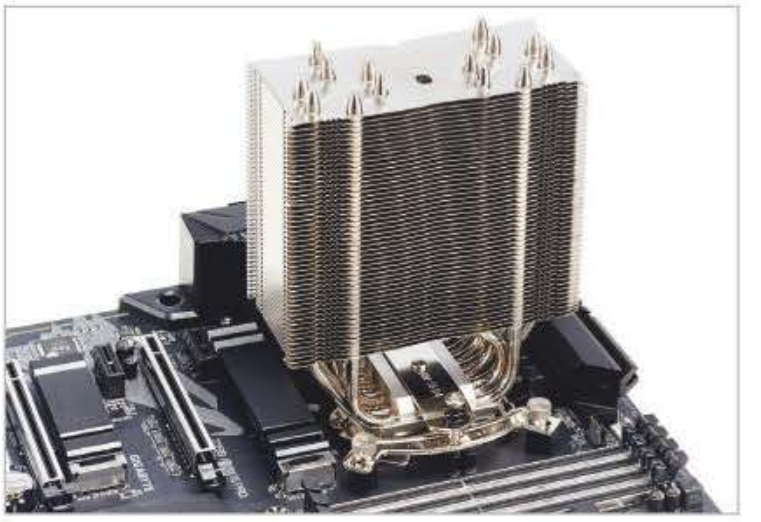
THE I9-9900K isn't too tricky to install. Release the metal retention arm from its clasp and lift it up, allowing you to flip the bracket up on its hinge. Line up the gold triangle on the corner of the processor with the matching triangle on the corner of the socket, then gently drop the chip into place. Lower the bracket back over it and return the retention arm to its original position.

Before we fit the cooler, put some thermal paste on the processor. The Noctua cooler we're using should come with a small tube of the ever-reliable NT-H1 thermal compound, so apply a pea-sized blob to the top of the processor and carefully spread it with a flat object like a credit card (don't use your actual credit card, though!).

6 PIPE DREAMS

TO FIT the seven-heatpipe Noctua NH-U12A, find the correct bracket in the box. The NH-U12A is compatible with most CPU sockets, so get out the LGA 1151 bracket and install it to the motherboard using the cross-shaped mounting plate that fits beneath the socket. Make sure the two standoffs on the bracket parts are facing upwards. If your cooler comes with the fans attached, remove them.

Once the bracket is in place, put the heat sink tower over the socket and line up the two spring-loaded screws with the standoffs. Apply pressure to the top of the cooler and loosely secure both screws before tightening them a little at a time. Again, don't over-tighten them, just make sure that the tower isn't going to budge.



9 MOUNTED INFANTRY

NEXT UP, we're going to mount the motherboard. This may be tricky, as the cooler and fans add significantly to the weight of the board, but installing it after mounting the motherboard is a less-desirable alternative.

Carefully lower the board into the case, lining up the central mounting peg and fitting the rear I/O into the cavity at the back of the case. Once in position, secure it using the small motherboard screws included in the Sekira case box. If you're unsure which screws are the right ones, take one and try screwing it into a standoff before mounting the board. Affix the central mounting peg's screw first, then the corners, then finally the four long edges.

10 GRAPHICAL PROWESS

BEFORE INSTALLING the GPU, remove two of the blanking plates at the rear of the case. This isn't as easy as in some other cases. Unscrew and remove the bracket that covers the tops of the blanking plates, then unscrew the plates, before replacing the bracket. The plates to remove are the second and third ones from the top of the case.

When removing the bracket, take care not to pop out the plastic panel in the center—we did, and spent 20 minutes trying to fit it back in. Once the plates are removed, install the GPU by opening the clasp on the PCIe slot and pushing the card down until it locks into place, then secure it to the case using the two screws from the blanking plates.

11 POWERING UP

UNBOX THE POWER SUPPLY and throw away most of the cables! Just kidding. We only need a few cables for this build, though, and the Fractal Design Ion+ 860P we're using here is fully modular, so we can cut down on excess cabling. Pictured here are the cables you'll need: one eight-pin CPU cable, one eight-pin PCIe cable, and the chunky ATX power cable.

There's an optional addition here that we recommend you take: One accessory cable for powering the RGB hub on the rear of the motherboard plate. This isn't strictly necessary for full functionality, but it does give you full lighting control of the 200mm RGB fans around the case.

12 WIRES CROSSED

WITH THE PSU SET UP, it's time to actually install this bad boy. Take four of the appropriate screws from the case's accessories box (the thick black Phillips screws with hexagonal heads). Slide the power supply into place under the PSU shroud, lining up the holes with the screw points on the back of the case, then screw it into position.

Feed the main three power cables through the holes in the motherboard mounting plate to plug them into the relevant ports on the motherboard and GPU. After that, route the accessory cable along the base of the case and up to connect it to the power connector from the RGB hub.

13 MIDDLE MANAGEMENT

WITH THE POWER CABLES ALL CONNECTED, move on to the I/O cables. The Sekira 500X has plenty of these; crucially, the power switch and HD audio cables need to be threaded along the underside of the PSU shroud, so that they can pass through the rubber-necked hole to the bottom edge of the motherboard where they plug in. The USB I/O connectors can be fed through the gaps further up—you may need to release some of these cables from their Velcro straps in order to give yourself a bit more slack to work with.

Lastly, plug in all the case fan power cables. Be sure to re-secure any loose cables, either using the included Velcro straps or by affixing them to the numerous metal anchor points with cable ties.

14 CLOSING TIME

OUR SYSTEM IS COMPLETE! Just a few final spot checks before we're ready for launch. When happy with the cable management and confident that everything inside the case is secure, return the two glass side panels to the case by gently lowering them back onto their hinges and swinging them shut. These snap shut when closed properly, but make sure the cables are tidy, as it only takes a small amount of pressure from inside the case to push them open again.

Once the doors are shut for good, plug the system in and power it up. We're ready to start testing! Don't forget to enable XMP in the motherboard BIOS to ensure that you're getting full speed from your memory.

1 **These hefty 200mm fans are impressively quiet even under load. The lighting effects they offer are great, too.**

2 **The Dominator Platinum RGB memory can be customized in Corsair's iCue software to display useful information in real time, such as component temperatures.**

3 **The PSU shroud allows room for storing excess cable lengths, and packs four toolless HDD trays for expanding on your storage if needed.**

A CASE IN POINT

UNSURPRISINGLY, this system beat the living daylights out of our 1080p zero-point system in almost every benchmark. The Samsung 960 Evo in our comparison machine secured the win over Corsair's MP510 SSD, but otherwise this system excelled in all areas, as expected. If you're looking to build this machine, we'd recommend upgrading to a newer graphics card—perhaps one of those shiny RTX 3000 series cards! But as we said, this was never just about the benchmarks.

We also did some temperature testing here, and you'll see the same tests in future case reviews (ATX cases, anyway). One of the key things we were looking at is how well the system dissipated heat, and how the case's fans and airflow design affected this. Of course, we needed a baseline for our baseline: This system was manually overclocked to 4.5GHz at 1.2V, and the GPU clock speed set to 1,750MHz (using MSI Afterburner). We also ran XMP, so we had full memory speed. This ensured that we had a fixed performance point for the system, without intelligent features like Intel's Turbo Boost creating heavily varying temperatures.

For testing, we monitored component temperatures during our regular benchmarking process, but then we took things one step further with duration stress testing. We ran the blended system stress test in Prime95 for a full hour, then 3DMark's Fire Strike benchmark looped for an hour as well, with half an hour of idle time for the system to cool down between tests.

During general testing, the Noctua NH-U12A held up well, and the MPG Sekira 500X's five case fans did a good job of forcing air through the case. Airflow isn't incredible in this build, since the front panel and roof are entirely solid and air must be drawn in through the narrow grilles on the edges. The highest CPU temperature we saw was 64C, specifically during the Cinebench R15 test. Temperatures during the gaming benchmarks mostly sat within the 60C area.

The idle system temperature was around 28C, only slightly higher than the ambient room temperature. The PWM fans calm down when the system is idling, so this machine isn't too noisy. After blasting the system on all 16 threads with Prime95 for an hour, our CPU temperature was 66C, with highs of 76C and lows of 62C. Not bad, then, especially since we're using air cooling. The glass and metal of the case itself didn't get warm at all.

During the 3DMark test, the CPU reached a maximum temperature of 70C, but the GTX 1080 rose all the way up to 82C and took a while to cool down due to its single, puny blower fan. The system as a whole ran relatively cool, though, with the motherboard never recording temperatures in excess of 44C and the case itself remaining cool and quiet. Props to MSI for this one!

BENCHMARKS

	ZERO-POINT	
Cinebench R15 Multi (Index)	1,152	2,034 (77%)
CrystalDisk QD32 Sequential Read (MB/s)	3,400	3,103 (-9%)
CrystalDisk QD32 Sequential Write (MB/s)	1,720	1,053 (-39%)
Tom Clancy's Ghost Recon Wildland (fps)	39	68 (74%)
Total War: Warhammer II (fps)	46	77 (67%)
Rise of the Tomb Raider (fps)	60	122 (103%)
3DMark: Fire Strike (Index)	11,101	19,267 (74%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our zero-point consists of an AMD Ryzen 5 1600, 16GB Crucial Ballistix Sport LT @ 2666MT/s, an EVGA GeForce GTX 1060 3GB and a 250GB Samsung 960 Evo M.2 PCIe SSD. All tests performed at 1080p at the highest graphical profile.

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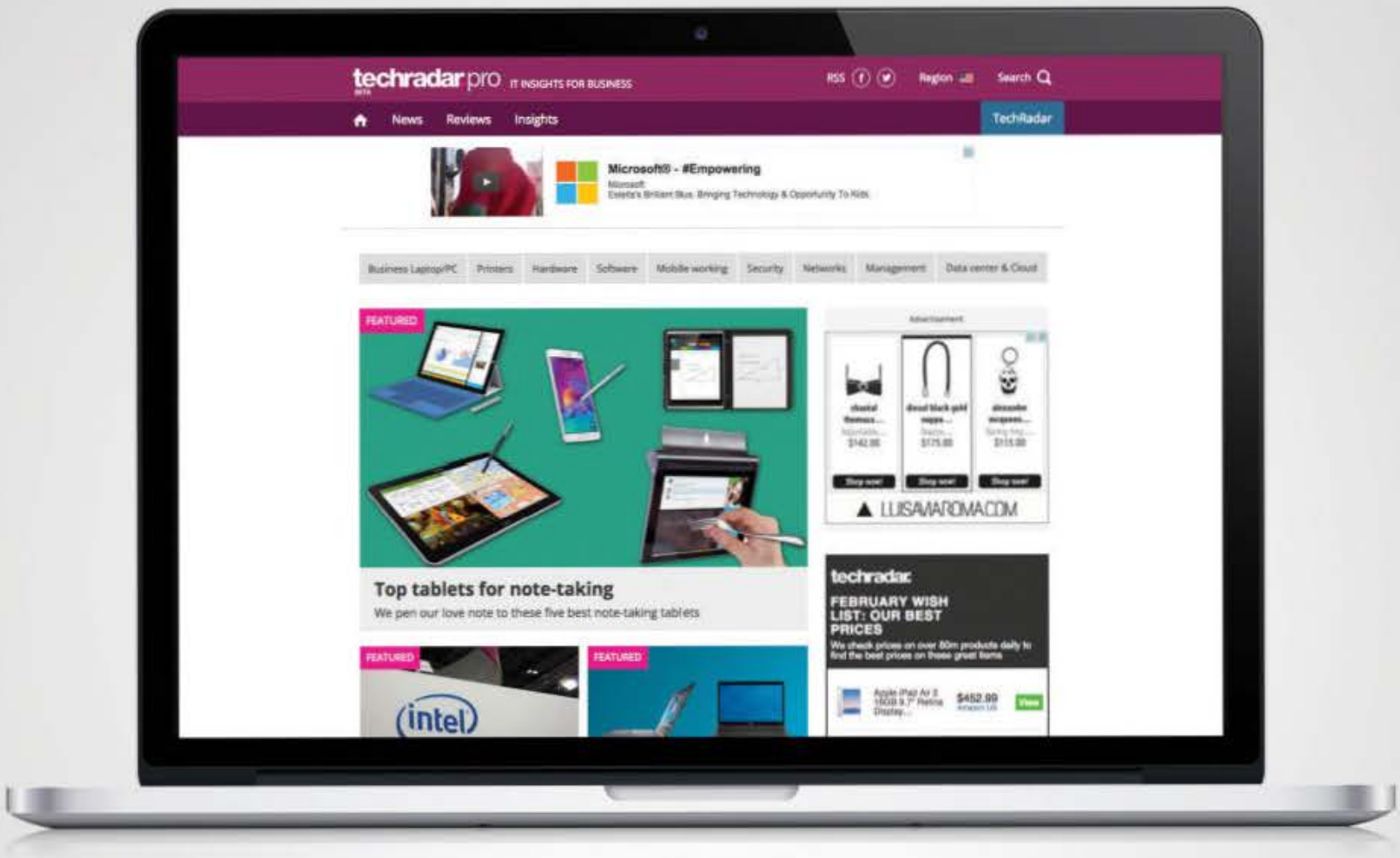
IT INSIGHTS FOR BUSINESS



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AMD RYZEN 9 3900XT PAGE 68

With Ryzen 4000 right around the corner, this doesn't quite make sense.

AMD Ryzen 9 3900XT

Incremental increases

THE AMD RYZEN 9 3900X was released exactly a year ago today, and we loved it. Loads of cores and decent gaming performance made it one of our favorite processors. On paper, this brand new Ryzen 9 3900XT takes that impressive chip and squeezes just a little more power out of it. The base clocks are unchanged at 3.8GHz, but the boost goes from 4.6GHz to 4.7GHz. Yup, a whole 100MHz.

You may be wondering how AMD has managed to squeeze an extra 100MHz out of this chip, even if it is only at boost, and apparently it's down to a better understanding of the 7nm production process. There are no other changes, though. The core and thread counts are the same, the cache levels are unchanged, and there are no tweaks to the underlying architecture.

What is different, compared to the existing 3900X, is that you don't get the Wraith Prism cooler with the 3900XT. So essentially you gain 100MHz to the boost clock and lose a cooler for the trouble. While there is certainly an argument for the 3900XT being at the limit of what the Wraith Prism can handle, and that plenty of builders will want to go down the AIO route for such a high-end chip, having the option of doing so is very different to being forced to.

The Ryzen 9 3900XT, like the 3900X before it, is a beast of a mainstream processor. 12 cores and 24 threads gives you lots of raw power if you're a content creator that needs to produce videos and/or dabble in some 3D rendering. The only problem here is the 3900X, which really isn't that far behind. You're looking at a four percent difference in video encoding, and three percent in the multi-core result from Cinebench R20. So, not a lot.

For testing we used a Corsair iCue H115i RGB Pro XT all-in-one cooler to keep the chip chilled, and the 3900XT did manage to hit its rated boost speed, topping out at 4.725GHz, with the overall CPU temperature topping out at 79°C. It tends to hit its maximum frequency only very briefly though, and for more thread-conscious loads the chip operates at around 4.2GHz.

The good news with the Zen 2 architecture is that it's a competitive chip in the gaming arena as well. It's true that Intel still has the overall lead, but the delta is slight, especially when working with higher resolutions.

The other factor that works against the 3900XT, and against all of these new chips, is that though there has been no official price drop from AMD for the 3900X, 3800X, and 3600X, they can generally be picked up for less if you scout around a bit. In the case of the 3900XT, this is more keenly felt. The chip it is aiming to replace can be picked up for $419, and that comes with the Wraith Prism cooler.

Which all adds up to make the 3900XT the least exciting of AMD's new XT chips. It isn't a bad processor—far from it—but this latest spin is not particularly interesting either. It arguably represents a drop in value compared to the chip it is replacing due to the lack of cooler, and brings very little extra performance to the table. If you've already got your mind set on serious cooling, and you need this many cores, then it's a consideration, but given the drop in price of the 3900X, we don't see this as an extra $80 well spent for essentially the same performance.

Then there's the spectre of Zen 3 that is set for release before the end of the year. With only a few months to go until that drops, is this really a good time to pick up a high-end Zen 2 chip? **–ALAN DEXTER**

BENCHMARKS

	AMD Ryzen 9 3900XT	AMD Ryzen 9 3900X
Cinebench R20 Single (Index)	**528**	509
Cinebench R20 Multi (Index)	**7,205**	6,989
X265 v5.0 Video Encoding (avg fps)	**63.58**	60.75
SiSoft Sandra Memory Bandwidth (GB/s)	**37.82**	35.23
3DMark Time Spy (Index)	**13,985**	13,662
Civilization VI AI Test (seconds)	**6.47**	6.88
Total War: Three Kingdoms @ 1080p	**132**	131
Far Cry New Dawn @ 4K	79	**81**

Best scores in bold. Our test bed consists of an Gigabyte X570 Aorus Master, 16GB Thermaltake DDR4 @ 3600, an Nvidia GeForce RTX 2080 Ti, 2TB Sabrent Rocket PCIe 4.0 SSD, and a Corsair H115i RGB Pro XT. All games were tested on the high profile.

VERDICT **8**

AMD Ryzen 9 3900XT

PINNACLE Strong overall performance; solid architecture.

INCREMENTAL No bundled cooler; poor value proposition.

$499 www.amd.com

SPECIFICATIONS

Cores / Threads	12 / 24
Base / Turbo Clock	3.8 / 4.7GHz
Architecture	Zen 2
Lithography	TSMC 7nm
Memory Support	DDR4 @ 3200MHz
PCIe Support	16+4 PCIe 4.0
Integrated Graphics	N/A
TDP	105W

MSI Raider GE66

Raiders of the lost laptop

LET'S NOT BEAT about the bush here: for us, MSI's laptops are sometimes hit and miss. Performance is always solid, with all the latest tech crammed inside the chassis, but the chassis is often the problem; chunky, ugly plastic casings and poor display choices mar what would otherwise have been excellent laptops.

The Raider GE66 is the successor to the GE65, a laptop that essentially reviewed everywhere as "really good, but looks a bit terrible." The GE66 doesn't do much to differentiate itself from its predecessors in that arena, but it does make several key improvements elsewhere.

The big pull here is a shiny new 10th-generation Intel processor, specifically the i9-10980HK in our review model (other configurations are available). That's bringing eight high-speed cores to the party, which combined with the RTX 2080 Super Max-Q GPU and 32GB of memory makes for one seriously competitive gaming laptop. It's not the most powerful on the market, but for $2,700 it's a reasonable proposition that can handle 1440p and even 4K gaming. The GPU also gives us access to ray-tracing in selected games, but it's not really worth the hit to frame rates and will make this Raider noisy as hell.

Let's talk about noise, actually. With its 15.6-inch screen and flat SteelSeries-brand keyboard, the GE66 is surprisingly compact. Unfortunately, this means that heat buildup can be an issue—you won't be able to game with this laptop on your lap. The twin fans on the underside go hard when the system is under load, screaming at full speed the whole way through our benchmarking process.

So it's powerful, but loud; not much different to most high-end gaming laptops we look at, then. But don't worry, MSI has other ways to make the GE66 stand out from the crowd. The 300Hz display is a good starting point, guaranteeing the crisp frame rates that are a must-have for serious esports gamers. A high-speed 1TB M.2 SSD means that lengthy load times are a thing of the past, while the upgraded 1080p webcam is great for impromptu streaming or Zoom calls.

IT'S THE MILEAGE

One of the most-touted upgrades to the Raider is the new battery, which is a whopping 99.9Whr unit. This battery can handle two entire movies or a good few hours of gaming between charges, which combined with the new (slightly) lighter design makes the GE66 a fair bit more portable than previous Raiders. Performance is obviously a bit better when plugged in, but it's still impressive. Why 99.9Whr, you ask? Well, a 100Whr battery can't legally be transported as checked luggage on international flights, so that acts as a sort of soft limit for what laptop manufacturers can sensibly produce and roll out.

The trackpad is a tad smaller than we'd like, but that's not a deal-breaker. The keyboard benefits from SteelSeries's RGB lighting software, which also links to the funky lightbar spread along the base of the chassis. We were apprehensive about the latter addition, but the lighting is actually quite subtle, creating a soft glow that appears to spill out from under the laptop. The keys themselves have a reasonable amount of travel and good physical response.

Despite its improved portability, the Raider GE66 retains a desktop-replacement port layout. USB ports and the 3.5mm headphone jack are easily accessible at the sides, but charging, Ethernet, and display ports are all situated on the rear for easy cable management at your desk. Unfortunately, this doesn't look great; the GE66 keeps the chunky rear segment seen on other powerful MSI laptops, rather than positioning the screen hinge all the way at the end of the chassis base.

Besides the outdated plastic chassis, though, the GE66 is a strong choice of gaming laptop. Our only other criticism would be the underpowered speakers, but given the price point we can't complain too much. They're lackluster but perfectly functional. Beyond that, it's easy enough to recommend this Raider.

–CHRISTIAN GUYTON

VERDICT 8

MSI Raider GE66 10SGS

INDIANA JONES Solid all-round performance; bright 300Hz display; powerful battery.

RENE BELLOQ Fans are noisy; runs hot; chassis is still ugly.

$2,700, msi.com

GAMING LAPTOPS BENCHMARKS

	ZERO-POINT	
Cinebench R15 Multi (Index)	1,030	**1,759** (71%)
CrystalDisk QD32 Sequential Read (MB/s)	3,374	**3,461** (3%)
CrystalDisk QD32 Sequential Write (MB/s)	**2,530**	2,398 (-5%)
3DMark: Fire Strike (Index)	13,610	**19,556** (44%)
Rise of the Tomb Raider (fps)	92	**122** (33%)
Total War: Warhammer II (fps)	62	**86** (39%)
Tom Clancy's Ghost Recon: Wildlands (fps)	49	**66** (35%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Best scores in bold. Our gaming laptop zero-point is the Acer Predator Triton 500, with an Intel Core i7-8750H, Nvidia GeForce RTX 2060 Max-Q, and 16GB of DDR4-2666. All game tests are performed at 1080p at the highest graphical profile.

SPECIFICATIONS

CPU	Intel Core i7-10980HK
Graphics	Nvidia GeForce RTX 2080 Super Max-Q
RAM	32GB DDR4 @ 2666MHz
Screen	15.6-inch IPS 1080p screen @ 300Hz
Storage	1TB M.2 NVMe SSD
Ports	1x SD card reader, 1x HDMI, 1x Mini-DisplayPort, 2x USB 3.2 Gen1 Type-A, 1x USB 3.2 Gen2 Type-A, 1x USB 3.2 Gen2 Type-C, 1x USB 3.2 Gen2x2 Type-C, 1x RJ45 Ethernet
Connectivity	Killer Wi-Fi 6, Bluetooth 5.1
Weight	5.25lbs
Size	0.9 x 10.5 x 14.1 inches

The 300Hz display is wonderfully crisp and colorful.

Hydra Mini

Simplicity is the ultimate sophistication

AS CHASSIS DESIGN goes, this is the most extreme example of minimalism we've ever seen. There's no frills here, no excess garnish or gaming flair, there's no support for crazy, over-the-top liquid-cooling, and you can't make it into a glorified NAS with hundreds of TBs of storage. The reality is that the Hydra Mini is a true manifestation of pure, clean, functional style, merged with exceptional craftsmanship and an attention to detail that makes it perhaps one of the most interesting cases we've ever had the pleasure of reviewing. That's not to say it doesn't have its flaws, and we'll cover those in due course, but despite that we can't help but admire this thing.

So what exactly is the Hydra Mini? Well, it's a tiny ITX SFX chassis that is built by a small Italian company called Hydra. It's available in three different color skus (white, black, and a clear satin finish, the latter being slightly cheaper). You can buy the Mini in a bundle, which includes a Hydra-branded PCIe riser extension for your GPU, at around $112 or $105 (not including shipping/import duties), or you can go for the standard case for just $78, or $65 for the satin steel variant.

The chassis itself is a single piece of powder, or clear-coated, 1.5mm folded stainless steel, completed with four machined aluminum feet. Straight out of the box you do have to attach the GPU bracket to the back of the case, but that's not necessarily a downside, depending on your graphics preference. Outside of that, and its rear mounted vertical GPU, it follows a traditional design style. Your motherboard is installed vertically in the usual orientation, and there are cutouts for your 24-pin ATX power and that PCIe riser in the bottom as well.

For the front I/O all you get is a single LED DimasTech power switch—which you need to install yourself—with black-sleeved cables. On the one hand we could criticize that, but given the overall size of the Mini, the distance between the front I/O and the rear I/O is less than a foot, if you do need to plug in anything there. Additionally on the back of the chassis, there are cutouts for some cable ties, and it also supports a single 2.5-inch drive, along with an SFX PSU.

If you do install a graphics card it's only supported by that rear bracket, and nothing else. The PCIe riser doesn't mount to anything directly, which can be a little daunting, but we've had no problems with it so far. On top of that the CPU and GPU power cables require a bit of work to get them tidy, but once strapped in and secured with cable ties, they look very clean.

NO-FRILLS FUN

Temps on the whole are impressive, thanks to its unimpeded access to cool air. And rather surprisingly, although it gets dustier faster than a regular case, it's ridiculously easy to clean—just hit it with a tin of compressed air once a week.

The biggest bugbear we have is the Hydra logo cutout. It goes straight through the steel, so if you have a power supply with a white specs label on it like we do, it shows through to the front. We're actually working with our resident peripheral reviewer/modder to design a frosted perspex backplate to slot in behind it—that way we can hide the PSU label and add an extra touch of lighting with some LEDs.

All that said, the Hydra Mini is still a fantastic-looking chassis, with exceptional materials, at an incredibly affordable price. Its small design makes it ideal for anyone who's looking to create a sleek, air-cooled gaming, home-theater or office PC, with or without a graphics card. It's easy to clean, easy to build on, and looks fantastic when you're done. **–ZAK STOREY**

VERDICT **9** KICK ASS!

Hydra Mini

HERCULEAN Bold design; seriously cheap; looks fantastic once built; easy to clean; strong performance.

MARVEL Cutout needs work; extended GPU bracket would be nice.

$112 www.hydra-shop.com

SPECIFICATIONS

Motherboard Support	ITX
2.5 / 3.5-inch Support	x1 / x0
Max Radiator Support	N/A
Fan Support	N/A
Dimensions	10.4 x 5.1 x 8.3 inches
Graphics Card Clearance	Unlimited Dual Slot
CPU Tower Clearance	Unlimited

Corsair 4000D Airflow

Obsidian meets 2020

A COUPLE OF ISSUES back we waxed lyrical about Corsair's first foray into the world of "gaming" office chairs. It's not exactly a complex formula designing a chair. In fact there are ergonomic truths that mean inevitably you're going to have a metal frame, five legs, a hydraulic riser, and generally the same design as practically almost every company out there. If you've built one chair from one brand, it's likely you'll be able to build any from all of the others. You'll recognize the same bolts, the same fixtures, the same process. It's all very similar. That's a good thing, as it means you're always going to end up with a quality product, as it's a tried and true design. Don't fix what ain't broke, as the old saying goes.

The thing that made that Corsair chair stand out in particular, however, was the little extra touches the company added onto the product—the rubber Corsair caps to plug the screw holes, the padded side-walls on the seat, the comfortable "carbon fiber-finished" arm-wrests, the super-slick wheels. These tiny things made a big impact.

Now what the heck does that have to do with this latest case you're looking at here? Well, this is Corsair's 4000D Airflow chassis. It's the first in a new line of refined and redesigned products from the company, featuring a whole new naming scheme. The aim is to get rid of some of that number confusion that it currently has with its products. The first number (in this example, 4) denotes the size of the chassis, with the following numbers and letters signifying class and design style.

The 4000D Airflow is something quite different from what we've seen from Corsair in the past few years. It's a sort of symbiotic merging between the impressive performance of Corsair's somewhat eccentric iCUE 220T Airflow series, and the smooth and subtle lines of its now-ancient Obsidian lineup from way back in the early 2010s. There's a hint of NZXT and Phanteks about it all. It's a formulaic entry incorporating some of the best design choices out there on the market today, for anyone looking to build a solid and dependable gaming PC.

That said, in a similar manner to its T-series gaming chairs, the 4000D has these small, subtle touches that really amplify its potency. The retainable thumb-screws on the panels are solid items to help with grip. There's a yellow rubber Corsair label attached to the removable top magnetic dust filter. There are cable channels in the back of the chassis to help with cable management, with pre-installed, Corsair-branded Velcro straps. The front airflow panel sits a good inch away from the fans and intake dust filter. You've got a full-size PSU cover, complete with support for vertically mounted dual-slot GPUs. There are ample cable cut-outs internally, and a cable bar lining the interior with Corsair's subtle new logo and branding imprinted on its side, and perhaps most impressive of all is the inclusion of two static pressure-optimized fans as well. Even the paint used has a soft-touch, fingerprint-resistant, matt finish.

Couple all that with support for multiple radiators, USB type C on the front I/O, two color skus (black and white), and a solid front panel variant as well, all for one single price of $80, and it's stupidly difficult to try and criticize this case. If we had any concerns it'd simply come down to the fact that the twin-slot vertical GPU mount might be a bit too skinny if you're looking at the new 3000 series from Nvidia, and support for hard-drives amounts to two 3.5-inch drives, and two 2.5-inch drives (simultaneously). But aside from that? Well heck, this might be the new budget king chassis. If we could give it a 10, we would. **–ZAK STOREY**

VERDICT 9 KICK ASS!

Corsair 4000D Airflow

OBSCENE Impeccable design; small touches; super price point; 4 skus.

OBSOLETE Vertical GPU mount might be too skinny.

$80 www.corsair.com

SPECIFICATIONS

Motherboard Support	E-ATX, ATX, M-ATX, ITX
2.5 / 3.5-inch Support	x4 / x2
Max Radiator Support	Front: 360mm, Top: 280mm (with LPX RAM), Rear: 120mm
Fan Support	Front: 2x140/3x120, Top: 2x 120/2x 140, Rear: 1x 120
Dimensions	17.8 x 9.06 x 18.4 inches
Graphics Card Clearance	14.17 inches
CPU Tower Clearance	6.69 inches

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GMMK Compact Barebones Keyboard

A small, mighty keyboard you can build yourself

COMPARED TO MANY peripheral companies, Glorious PC Gaming Race is the new kid on the block. It has been around for about six years now, and in that time it has made a huge impact on the peripheral scene. The Model O mouse is one of the best-selling mice of recent years, and the GMMK full-size and TKL are both highly respected, claiming to be the first hot-swappable modular mechanical gaming keyboard.

Today we have the GMMK Compact Barebones. This is a 60 percent keyboard for those who appreciate the smaller things in life, without a numpad, arrow keys, and F-row. To access these you use FN + I,J,K,L for your arrow keys, and FN + numbers for your F keys.

The "Barebones" part of the name is the most interesting thing about the GMMK series for us. This means you can select your components for the keyboard yourself. You have the choice of a full-size, TKL, or 60 percent board, so if the compact isn't your thing, then there are other options. As well as being able to choose the size of your keyboard, you also have the option to choose from 14 different switch types. We chose Kailh Pro Purple switches, which are similar to Cherry MX brown but actuate slightly heavier. If Cherry MX switches are your preferred choice, however, you will have to get these separately, as currently there are only Gateron and Kailh variants, which if we're honest are perfectly fine.

The last selection is the keycaps. Here you can select either the standard black or white caps, or you can have the RGB-loving pudding keycaps, also in black or white variants. You can also select optional o-rings to dampen typing noise if you so wish—we didn't worry about that. We chose the white pudding keycaps, and we can certainly see why they are garnering popularity in the RGB crowd. They're very pretty when the light glows through them.

KNEE BONE'S CONNECTED TO...

Building the Barebones keyboard is child's play. The GMMK Compact has hot-swappable switches, so no soldering is needed; you simply push the switch into the PCB. It is worth noting that you can bend the copper terminals on the switch if you push them in at an angle, so best practise is to sit directly over the keyboard so you can push straight down. This isn't an issue with the GMMK itself—it's the same with all hot-swappable keyboards. If you do bend anything, Glorious has included tweezers to help you straighten things up, and you also get spare switches.

We don't have much space left for how well the keyboard performs, our typing experience, or the software, but honestly we don't need it. It performs great, the typing experience is as expected because we chose the switches, and the software is simplistic but works.

The only issues we found were nit-picky ones, such as not being able to bind media keys to secondary FN keys. This means you're very limited on where you can actually use them. The second niggle is that there is no on-board memory. Changing options in software and hitting apply will work, but as soon as you move to a secondary system you're back to default settings. They're not major issues, but other keyboards have this area locked down, so it would be nice for Glorious to do the same.

Overall, the GMMK Compact is probably one of the best keyboards we've tested in a while thanks to being so customizable. We can choose the options we want before adding it to the cart, so it's naturally going to fit our personal preference and score higher, as it ticks all our boxes. Usually, to do the same you'd have to delve into the custom keyboard scene and spend far more. **–DAVE ALCOCK**

VERDICT 9

GMMK Compact Barebones Keyboard

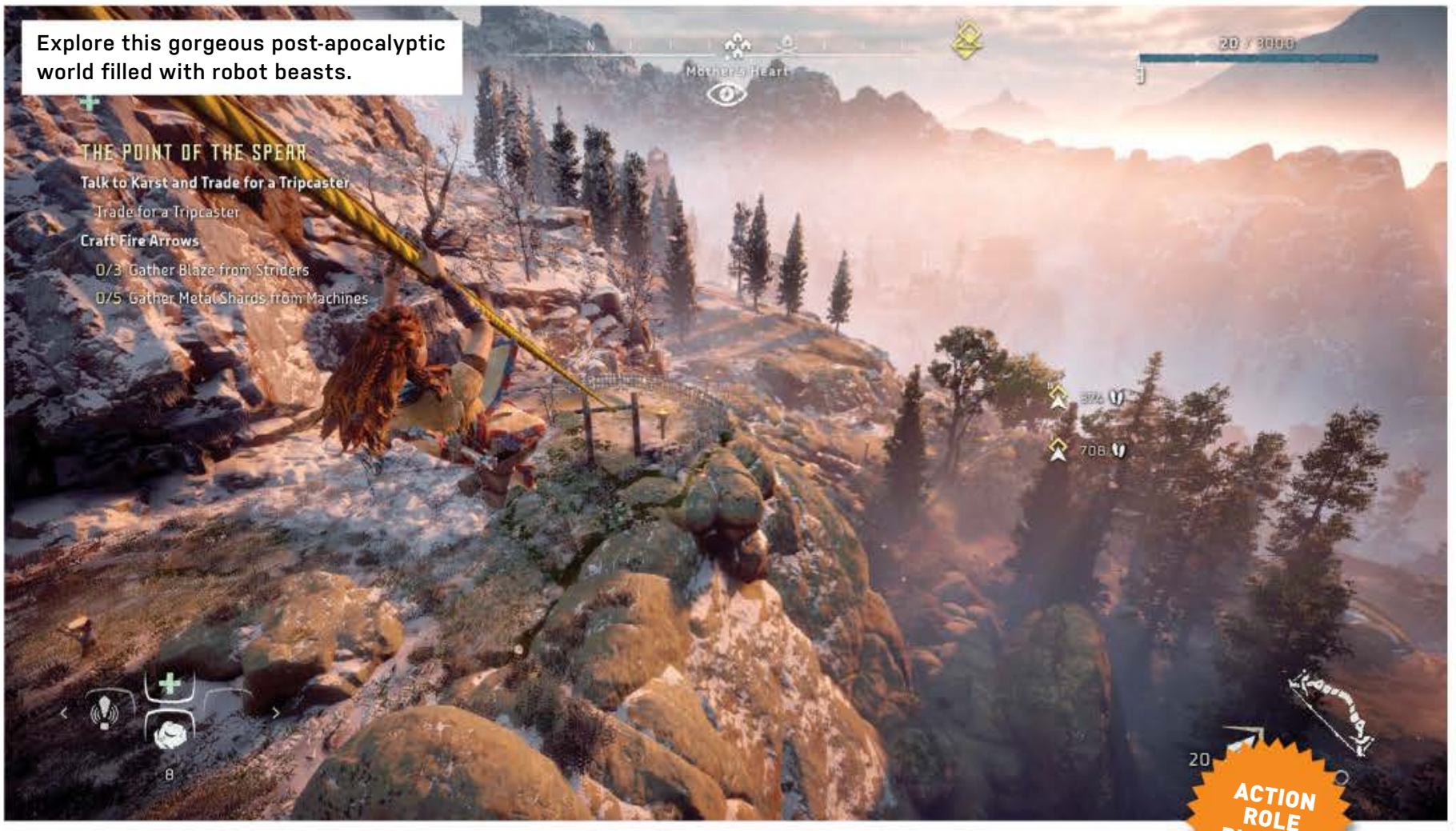
GLORIOUS Ridiculously customizable; great to type on; beautiful-looking pudding keycaps.

SNORIOUS Limited pre-built options; unable to set keys on multiple layers; no on-board memory; no Cherry MX options; software simple but limited.

$120-$138 www.pcgamingrace.com

SPECIFICATIONS

Form Factor	60%
Switch Type	Kailh Purple
Keycaps	ABS
Media Keys	Available
Connection Standard	Detachable USB Type C
Number of keys	61
Weight	1lb 12.2 oz
Dimensions	11.5 x 4.0 x 1.7 inches


Explore this gorgeous post-apocalyptic world filled with robot beasts.
THE POINT OF THE SPEAR
Talk to Karst and Trade for a Tripcaster
Trade for a Tripcaster
Craft Fire Arrows
0/3 Gather Blaze from Striders
0/5 Gather Metal Shards from Machines
ACTION ROLE PLAYING

Horizon Zero Dawn Complete Edition

Oh give me a home, where the robo-buffalo roam…

MANY OF THE GAMES that come to *Maximum PC* have issues, and we're usually fairly kind about them, as we are often told there will be a day-one patch to fix the problems. So what's *Horizon Zero Dawn*'s excuse? It's a three-year-old game originally made for the AMD-powered PS4, and didn't have a holiday or multi-system release window to hit. How was it released in this state when *Death Stranding*, which runs on the same engine, was such a strong port?

You see, it's a bit crashy. The PC port of *HZD* has many things to recommend it, but stability isn't one of them, returning us to the desktop about 50 percent of the time with no noticeable trigger event. And despite the wealth of graphics options, obtaining a smooth frame rate can be difficult too. Hopefully, this will all be fixed by the time you read this, but it represents the game around its launch. It's a shame, as when *HZD* is good, it's very good.

More of a stealth-action-adventure in the mold of later *Assassin's Creeds*, *HZD* casts you as Aloy, a female outcast who is easily as boring as any male game protagonist we've seen recently. She works and trains hard to rejoin the tribe that cast her out, and is sent out into a far-future post-apocalyptic world populated by robots in the form of grazing herds, stalking predators, and dinosaur-like giants. The robots gain power from eating biomass, and act very much like the animals they outwardly resemble.

From the leather and feathers of the primitive tribe to the sleek cybernetics of the robots, it's a gorgeous world: Sunrises fill the world with glorious reds and oranges; weather effects ripple across the lands; swaying foliage glows at night so you know where the hiding places are.

The story stays on the right side of cliché, never going for the obvious—wholesome tribe overrun by nasty modern machines—instead weaving a narrative that constantly ups the stakes.

It's the machines that deserve the most accolades, though. When you first take out a velociraptor-like (*Jurassic Park* version) Watcher it makes you feel powerful. When you use a Strider as a mount you feel fast. And when you climb a Tallneck, thundering footsteps audible long before you see it, you feel like a king.

Human characters, outside of settlements, tend to appear in *Far Cry*-esque base-clearing missions, which don't play to Aloy's strengths. In single combat with a mighty machine she shines, but when stealth goes awry you quickly reach for the reload button.

HZD is a deep game that's hugely welcome on PC after three years on PS4. Despite its performance issues at launch, this is the best version of the game, bundled with its expansion. Aloy's story takes her to unexpected places, and this highly imaginative world is one that needs to be explored. **–IAN EVENDEN**

VERDICT 8

Horizon Zero Dawn Complete Edition

PURE Expansive world; exciting combat; can look excellent.

CORRUPTED Poor performance and stability at launch.

RECOMMENDED SPECS CPU, i7 4770K / Ryzen 5 1500X. RAM, 16GB. GPU, GTX 1060 (6GB) / RX 580 (8GB).

$50, www.guerrilla-games.com, T-rated

© GUERRILLA GAMES

Röki takes you on an adventure with young protagonists Tove and Lars.

With simple controls and a charming style, *Röki* is very accessible.

Explore strange, menacing Scandinavian folklore.

The game is underpinned by a touching family narrative.

ADVENTURE

Röki

Take a stroll through a deep, dark wood

HERE'S A LOVELY THING: An adventure game based on Scandinavian folklore, *Röki* casts you as Tove, capable elder sister of little Lars, who won't go to bed without his stuffed toy and a story. The story she chooses is one of four guardians, and it feels heavy with foreshadowing.

Lars is a playful boy, and sees trolls and monsters everywhere he roams, even if that's just to the bathroom at night. The siblings have a father, who does little but sit in his chair and eat pickled herrings, and the family is still hurting from the loss of their mother. Early comments from Tove about her father not keeping her mother's possessions show that this rankles just as much as having to cook eggs once again for dinner. It's a picture of domestic unease, the leaky roof of the small timber cabin they live in as much a metaphor for family life as the license plate falling off their father's beat-up car is for his condition.

There's a constant edge to all the Scandinavian coolness, however. Trove loves horror novels while Lars prefers fairytales, and the landscape is conducive to both. Pure white snow coats the forest, and the lake is a mirror of ice. A village clings to its edge, but Tove and Lars don't live there, they're isolated out in the forest, and when Lars imagines there could be a troll under the bridge, well, you kind of believe him. Ravens cluster around their home, remarked upon as a bad omen, and when something awful really does happen, the cold forest turns out to be even more infested with creatures than Lars could ever have predicted. Some of them are even friendly.

The adventure mechanics are smooth and well thought-out, perfectly designed for controller or mouse, if a little too reliant on pressing a single button to advance lines of dialog. A journal keeps you up to date on what you're doing and displays items you've found, while your backpack holds useful things, including snowballs. Open the backpack, and you can scroll through its contents before clicking and dragging to combine items or use them with objects in the environment. You can click to highlight all the interactive areas on a screen, and approaching them brings up an icon that tells you whether you're going to examine or collect them.

It really couldn't be simpler, and having such a smooth system underpinning your explorations makes the game's three chapters pass quickly as you find yourself deep in the forest, separated from all your family members, yet expressing a joy at your surroundings that can only come from such young protagonists.

If you see the game in a cold, analytical light, then it's just a bunch of fetch quests bundled up in some family stories to pluck at your heartstrings, backed up by just enough fairytale menace to make you wonder about all those stone statues that stand by the forest paths. But to look at it this way is to overlook the other light coming from the huge moon that looms over the children's home, or the winter sunlight that peeps through their bedroom window. There's a warmth to *Röki* that overcomes its wintry setting, and for a fairly short game it leaves a long-lasting impression. **–IAN EVENDEN**

VERDICT **7**

Röki

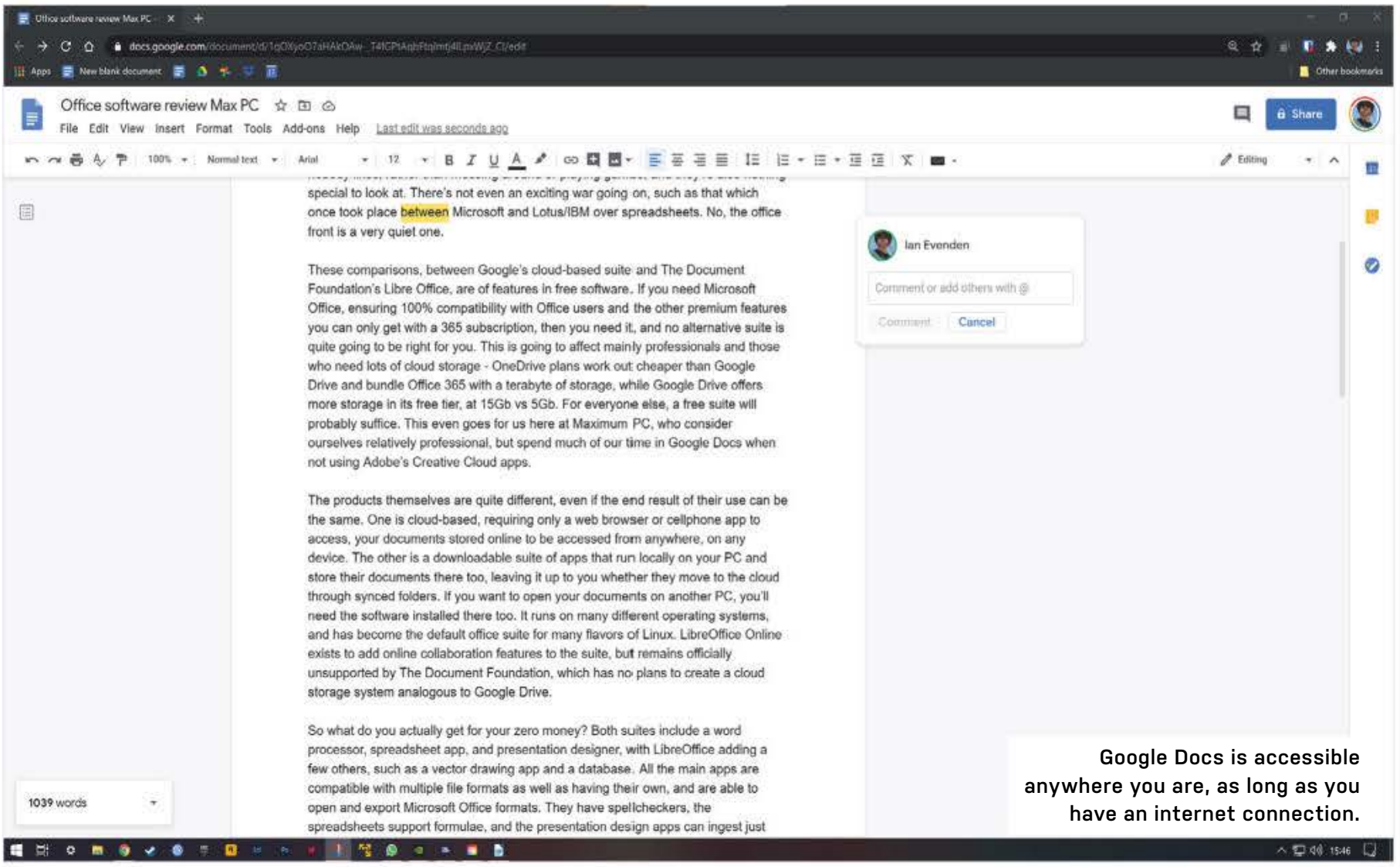
BRIDGE A fine intermingling of characters, landscape and adventure mechanics.

TROLL Slow; lots of fetch quests; final third removes many of the best bits that came before.

RECOMMENDED SPECS CPU, i5 4690k / Ryzen 5 1600. RAM, 8GB.
GPU: GTX 970 / RX 480.

$20, www.unitedlabelgames.com/roki, Rated T

© CI GAMES, UNITED LABEL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File Edit View Insert Format Tools Add-ons Help Last edit was seconds ago
Share
Editing
special to look at. There's not even an exciting war going on, such as that which once took place between Microsoft and Lotus/IBM over spreadsheets. No, the office front is a very quiet one.
These comparisons, between Google's cloud-based suite and The Document Foundation's Libre Office, are of features in free software. If you need Microsoft Office, ensuring 100% compatibility with Office users and the other premium features you can only get with a 365 subscription, then you need it, and no alternative suite is quite going to be right for you. This is going to affect mainly professionals and those who need lots of cloud storage - OneDrive plans work out cheaper than Google Drive and bundle Office 365 with a terabyte of storage, while Google Drive offers more storage in its free tier, at 15Gb vs 5Gb. For everyone else, a free suite will probably suffice. This even goes for us here at Maximum PC, who consider ourselves relatively professional, but spend much of our time in Google Docs when not using Adobe's Creative Cloud apps.
The products themselves are quite different, even if the end result of their use can be the same. One is cloud-based, requiring only a web browser or cellphone app to access, your documents stored online to be accessed from anywhere, on any device. The other is a downloadable suite of apps that run locally on your PC and store their documents there too, leaving it up to you whether they move to the cloud through synced folders. If you want to open your documents on another PC, you'll need the software installed there too. It runs on many different operating systems, and has become the default office suite for many flavors of Linux. LibreOffice Online exists to add online collaboration features to the suite, but remains officially unsupported by The Document Foundation, which has no plans to create a cloud storage system analogous to Google Drive.
So what do you actually get for your zero money? Both suites include a word processor, spreadsheet app, and presentation designer, with LibreOffice adding a few others, such as a vector drawing app and a database. All the main apps are compatible with multiple file formats as well as having their own, and are able to open and export Microsoft Office formats. They have spellcheckers, the spreadsheets support formulae, and the presentation design apps can ingest just
Ian Evenden
Comment or add others with @
Comment
Cancel
1039 words

Google Docs is accessible anywhere you are, as long as you have an internet connection.

Google Docs vs LibreOffice

The last word no longer belongs to Microsoft

OFFICE SUITES are a hard thing to get excited about. They represent actual work, which nobody likes, rather than messing around or playing games, and they're also nothing special to look at. There's not even an exciting war going on, such as that which once took place between Microsoft and Lotus/IBM over spreadsheets. No, the office front is a very quiet one.

These comparisons, between Google's cloud-based suite and The Document Foundation's LibreOffice, are of features in free software. If you need Microsoft Office, ensuring 100-percent compatibility with Office users and the other premium features you can only get with a 365 subscription, then you need it, and no alternative suite is quite going to be right for you. This is going to affect mainly professionals and those who need lots of cloud storage—OneDrive plans work out cheaper than Google Drive and bundle Office 365 with 1TB of storage, while Google Drive offers more storage in its free tier, at 15GB versus 5GB. For everyone else, a free suite will probably suffice. This even goes for us here at *Maximum PC*, who consider ourselves relatively professional, but spend much of our time in Google Docs when not using Adobe's Creative Cloud apps.

DIFFERENT APPROACHES

The products themselves are quite different, even if the end result of their use can be the same. One is cloud-based, requiring only a web browser or cellphone app to access your documents, which are stored online to be accessed from anywhere, on any device. The other is a downloadable suite of apps that runs locally on your PC and stores documents there too, leaving it up to you whether they move to the cloud through synced folders. If you want to open your documents on another PC, you'll need the software installed there too. It runs on many different operating systems, and has become the default office suite for many flavors of Linux. LibreOffice Online exists to add online collaboration features to the suite, but remains officially unsupported by The Document Foundation, which has no plans to create a cloud storage system.

So what do you actually get for your zero bucks? Both suites include a word processor, spreadsheet app, and presentation designer, with LibreOffice adding a few others, such as a vector-drawing app and a database. All the main apps are compatible with multiple file formats as well as having their own, and are able to open and export Microsoft Office formats. They have spellcheckers, the spreadsheets support formulae, and the presentation-design apps can ingest just about any graphics you throw at them. There's a lot of overlap in the capabilities of the two suites, and neither has a glaring hole where expected functionality should be.

Google Docs takes up no disk space, being entirely online, and scales nicely with your web browser to different viewport sizes. LibreOffice can look slightly pixellated when viewed on a 4K monitor, but this can be fixed with a trip to "Tools → Options" and changing to an SVG-based style of icons.

The other thing we find about LibreOffice is that, running on Windows 10 and an AMD CPU, it has a tendency

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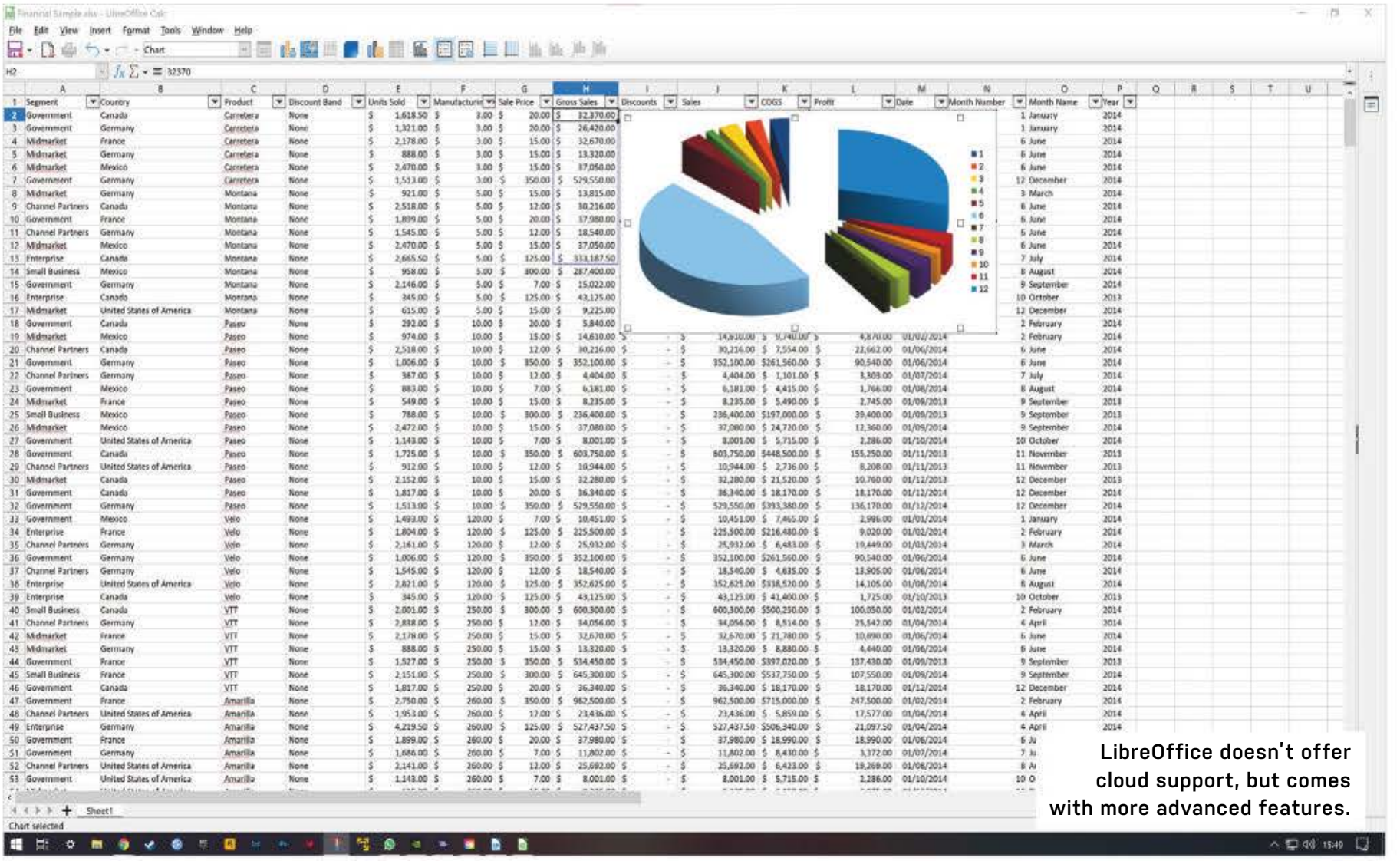


LibreOffice doesn't offer cloud support, but comes with more advanced features.

to crash. This is suboptimal in an office suite, and the fact it's happened with both versions 6 and 7 of the app makes us wonder if it's us rather than the software.

ADVANCED FEATURES

We tend to refer to the whole Google suite as "Google Docs," but this is a slight misnomer. Docs only refers to the word-processing app, with the spreadsheet called Sheets and the presentation app called Slides. There isn't really a name for the whole suite, unless you want to call it The Office Suite Offered By Google Within Its Google Drive Service, so Docs will do. After all, spreadsheet and presentation files are documents too.

As far as advanced features go it loses out to LibreOffice, but wins in terms of user collaboration. Along with Google features such as Gmail and Hangouts/Meet, which LibreOffice has no answer to, Google Docs files can be shared with a simple URL rather than attaching the entire file to an email, no matter how large the document. Multiple users can also work on the same file, while sharing privileges can be set so that some users can only view or comment.

Tracking changes, a frequently used way of collaborating on a written document, is achieved using comments, which show who made the suggested change but leave it up to the document owner to accept. LibreOffice tackles this in the same way as Microsoft Word, and leads in terms of features such as mail-merging and even the ability to show invisible formatting characters—Google relies on third-party plugins to add this kind of functionality.

For power users, Google apps are connected by Apps Script, a JavaScript-based service that enables you to develop add-ons to Docs, Sheets, Gmail, Calendar, and more. It runs in the cloud through a browser-based editor, and there's plenty of documentation online. You can do clever things with formulae and macros in Docs and Sheets too.

LibreOffice has its own macro-recording system, along with (incomplete) support for those created in Visual Basic for Applications. The Access2Base project provides a library of macros for developers that's designed to be easier to learn than LibreOffice's standard UNO API, and is particularly suitable for those familiar with the Microsoft Access way of doing things.

When looking for a free office suite, there are two main things to consider: Whether you want it to be completely cloud-based, and whether the tools provided by Google Docs are enough for you. If the answer to both those questions is yes, then using Google Docs is a straightforward decision. If you have a need to keep things on a single PC, or need tools not supplied in the web apps—which are simpler than their hard-drive-installed brethren—then LibreOffice is well worth a look. Both are completely free, unless you donate to The Document Foundation, so you lose nothing by testing them both out. –IAN EVENDEN

VERDICT 8

Google Docs

CLOUD Complete Google Drive integration; available everywhere; free up to a point.

RAIN Online only; missing some advanced features; more expensive than OneDrive.

RECOMMENDED SPECS Browser required: Google Chrome, Firefox, Internet Explorer 11, Microsoft Edge, or Safari.

$ Free, www.google.com

VERDICT 9

LibreOffice

SWEET Complete office solution; many advanced features,

SUITE Possibly a bit unstable; no cloud integration.

RECOMMENDED SPECS Microsoft Windows 7 SP1 or above, Pentium III processor or above, 256MB RAM, up to 1.5GB hard drive space, 1024x768 resolution.

$ Free, www.libreoffice.org

© LIBREOFFICE

LAB NOTES

DAVE ALCOCK, CONTRIBUTING EDITOR

The Perfect Key Switch?

There's nothing more magical than building the perfect board

ASKING SOMEONE about their favorite switch is akin to asking their age or weight. It's personal and can cause arguments. I mean, there are people who like Cherry MX Speeds—yuck! Personal preference plays a major role in selecting the right keyboard switch and, as a reviewer, I have to put my own preferences aside and be objective. But now I've been let loose and I can tell you what switches I like and why.

Basically, if the switch is heavy and has some kind of feedback, I'm all for it. Cherry MX Greens? Sure. Kailh Box Navy Blue? Let's go! Zelios 78cN? Yes please! My all-time favorites are modified NovelKeys Sherbets, mainly because they were white and orange, but also because I had 120cN springs in them. Typing on them was almost like using a typewriter. My hands, unlike the rest of me, were trim, defined, and full of muscle. Alas, I only bought a few to test and I haven't been able to get them again, so I usually use one of the other switches mentioned. Combine heavy switches with my love of compact 65% keyboards and blank keycaps, and we have a winner. It often makes LAN events or folks using my PC in the office end up with a rage quit, a look of disgust, and the feeling that spending your wages on keyboards and switches isn't for everyone. I realize that real switches aren't to everyone's taste, and occasionally build boards with lighter switches. I even go as light as an MX Red just to keep peeps happy.

Yes, those are super-sized mechanical switches.

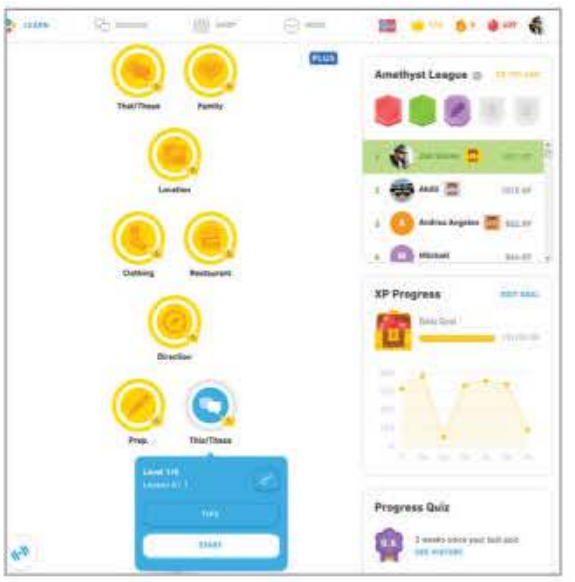
It is all down to personal preference, though, and no matter what you're told in reviews about switches, if you like a particular switch, you use it. A mechanical keyboard that has the wrong switch for you is worse than using a membrane board. You do you. Except Cherry MX Speeds. You can leave them with the pumpkin spiced latte and poor excuse for a beard.

INDUSTRY INSIDER

Nvidia has finally debuted its latest-gen GPUs, the RTX 3000 series, and they look like an awesome proposition. The RTX 3070 is supposedly as powerful as an RTX 2080 Ti, yet comes in at just shy of $500—that's nearly $700 off the Ti's RRP. It's a master stroke in terms of performance leaps, and one we're very keen to take a look at. But the most curious element for me is the RTX 3090. This is a mammoth card, a beast of a GPU, 24GB of GDDR6X, triple-slot, custom power connectors, and enough CUDA cores to simulate a planet. However, according to Nvidia, it's capable of driving 8K at 60fps and starts at about $1,500. Just a smidge more than the RTX 2080 Ti did two years back. This got me thinking. Most of the top-end enthusiasts I know run either a 3440x1440 superwide setup, or a 27-inch 1440p screen at 144Hz and above, with just a few 4K gaming guys out there. So the reality is the 3090 would be massive overkill, unless you're upgrading your monitor. The problem is, although 4K 60fps panels are now in abundance, anything above that will set you back $1,500-plus, so is the RTX 3090 worth it right now? Or will it be hindered by a lack of more affordable 4K panels? If the performance figures are true, it's a good jump, and a hell of a product, but the rest of the industry needs to catch up.

© GETTY IMAGES

Duolingo Plus



I MENTIONED, two issues back, that I was dropping gaming in favor of being more productive. Eventually, I intend to move to Norway and start a family there, so getting to grips with the language is of paramount importance. Naturally, as a tech enthusiast, I looked online to find a good place to start learning, and Duolingo caught my attention.

Duolingo is a website and a very well-regarded mobile app on iOS and Android, with which you can learn a multitude of languages, from French to Navajo. It sort of acts like a flash-card trainer. So, on desktop, you choose a subject from a progression tree—for example, Definite Plurals, Conversation, or Restaurant—then there's a "tips" section that runs you through the grammar rules, the vocab that'll come up, what you need to know, and how sentences come together.

Then hit "Start Lesson." You're given a series of questions, usually 20, each one a basic sentence, with varying forms of input. You might get a multiple choice one, or a word-bank question, or you might be asked to say the sentence into a microphone (you can turn that off), or type it in English or the language you're learning, or fill in the blanks—there's tons of options.

If you get stuck, hover the mouse over a word and it tells you its translation. And if you get the task wrong (or right), you can hit the "Discuss" button after submitting your answer, and it will take you to a forum page, where moderators, natives, and other Duo users are discussing that sentence, which can help a lot.

When you complete a lesson, you gain EXP, and it asks if you want to move on to the next one. Eventually, you'll rank up that topic through levels 0–5 (anywhere from 5–25 lessons), and it will go gold. After that, you can practise the topic whenever you want, and move on to the next one.

I personally do my language training on desktop devices. I usually have a Google Doc open on one side of the screen, where I write down notes and vocab, then do the practicing on the left.

Duolingo does have its flaws, though. It's too easy to get caught up in how much EXP you do a day, especially as it has leaderboards. Any language expert will tell you that it's not about how much you get done, it's more important that you're consistent and studying daily. Also, although it's great for single sentences, and learning words and grammar rules, it doesn't help with long paragraphs of text, or for quick conversational language. Plus, the mobile app lacks the tips section, and has limited "hearts" unless you go premium.

It's not a bad product, though. For instance, my Norwegian Bokmål course has 172 subjects to cover, and each one takes me a day or two to learn. So, there's a ton to pick up from that. Once it's done, I'll have to expand my learning further, by reading Norwegian literature, and watching Norwegian TV to pick up the conversational stuff. Another neat website I use is Forvo.com, a community-driven pronunciation dictionary. Enter a word, and there's a number of entries teaching you how to pronounce it, submitted by the community. In the more tonal languages, it can be massively helpful for getting your head around similar-sounding words. **–ZS**

$Free, www.duolingo.com

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EDITOR'S PICK

Christian Guyton,
Staff Writer

WARFRAME: HEART OF DEIMOS

It's been a while since I chatted here about my favorite game, hasn't it? Yes, free-to-play space ninja game *Warframe* is back with a major update, adding Deimos, the moon of Mars, as the game's third open-world region. Deimos is geographically a bit smaller than previous locations, but an enticingly vertical landscape and procedurally generated tunnels beneath the surface help to keep things feeling fresh.

Deimos is also completely wrecked. Disgusting organic tissue coats the moon, with a variety of new (read: gross) enemy types inspired by bugs and horror movie icons. That's right, this expansion has facehuggers—only these ones can fly. Even the guardians of Deimos, the ancient Entrati family, have succumbed to the infestation, able to communicate but trapped inside fleshy cocoons.

Gameplay-wise, this update has lots to offer. The core gameplay loop of previous expansions is still here, but this world is better tuned and better suited to unite *Warframe's* frequently disparate parts. The last open-world region added hoverboards; they make a reappearance here as Velocipods, giant insects you can ride around. There's still fishing, but these "fish" drift through the air and look particularly gruesome.

As always, there's a host of new loot. A bunch of new guns is always welcome, as is the ability to rescue wild animals and raise them as deadly pets. There's a new frame to play as: Xaku, who can turn into a freaky plasma skeleton. Oh, and there's big stompy mechs now, because *Warframe* values fun over logic.

Warframe remains a slightly odd, disjointed experience, but an overhauled tutorial goes some way to address this. I can't wait to see what the devs do next.

$FREE, http://warframe.com

LETTERS

WE TACKLE TOUGH READER QUESTIONS ON...

> $1,000 Hydra
> Data Clusters
> Refrigerated Computing

Where's Windows?

I would like to bring your attention to the fact that not every subscriber is a PC builder. I'm not.

I've been reading your magazine for several years, because of its Windows articles. In the latest editions, there is no mention of Windows. Your attention to this matter will be appreciated. **–Carlos H.**

EDITOR, ZAK STOREY, RESPONDS: That's a very good point, and I'll be honest with you: We haven't had the budget. Because Windows 10 has been around for so long, it's been difficult to justify the spend on it right now. I do perhaps have a bit too much of a hardware focus personally, but this is definitely something we should readdress. I mentioned in my "Editor's Intro" that we will be back up to our regular 100-page count (and 100% budget) as of our Holiday issue, so we can start bringing back our regular software writers.

In fact, we've already penned a particularly interesting "build your own media streaming server" feature for that issue, which will go into depth on how to set up your own DIY NAS at home using Windows, which might be of some interest for you. And next issue, Christian's taking a look at living-room gaming, and how you can stream from your main PC to your living room, or what alternatives there might be. But I hear where you're coming from, and we'll amp up our Windows coverage as soon as we can.

Budget Hydra?

Hi Zak, I loved your build with the Hydra Mini, and I would really like to build one. However, I wouldn't plan on using it for my main PC, or for work or gaming.

Having said that, I would like to see a budget build with this chassis. Is this possible? Can you list the components that would work and possibly bring the price down below $1,000?

–Alan Askinas

EDITOR, ZAK STOREY, RESPONDS: I utterly love this build. I'm still using it as my daily driver, in fact, in my home office, and it's a fantastic system. I've made some small modifications (increasing the amount of memory for *Star Citizen*), but it's such a nice machine to work with.

One of the best things about the Hydra Mini is the fact that it doesn't have any compatibility issues, outside of only supporting dual-slot cards and ITX mobos (and if I'm honest, that's a bit open to interpretation; I haven't popped a three-slot card in it yet, but I'm not too worried for when I do). If you want a really clean build that's a good all-arounder, I recommend this: https://pcpartpicker.com/list/QNKzb8

This falls about $9 shy of your $1,000 limit (with the added $111 for the Hydra) and gives you a really nice, balanced system that should allow you to do pretty much whatever you want. You get a nice six-core, 12-thread CPU, 16GB of DDR4, a 1TB PCIe SSD (albeit only 1,800MB/s sequentials), and an Nvidia GTX 1650 Super for your display needs.

If you're absolutely not gaming at all, but still want a beefy, fast, modern system, I recommend this: https://pcpartpicker.com/list/6khhn7—it's a bit different, so the CPU is the Ryzen 5 3400G coupled with 32GB of DDR4, a more premium mobo, and a 2TB Sabrent Rocket PCIe 3.0. I'd actually advise against this, though, as we should be seeing AMD's fourth-gen chips land by the time you read this, so there should hopefully be a Ryzen 5 4400G that has support for PCIe 4.0 drives, at which point I'd recommend a 1TB Corsair Force MP600 M.2 SSD instead. That might shave off more cash, in which case I'd grab the Noctua NH-L9a chromax.black to complete the look for an extra $40. Hope that helps.

Motherboards & Builds

I really appreciate the "Builds" section in the back. The addition of dual AMD and Intel builds is greatly appreciated for those who might prefer one or the other.

In the September 2020 issue, Gavin Bonshor's article on motherboards was priceless. Good information that filled in a lot of holes.

A long-time subscriber, I have designed and built many of my systems, and

↘ submit your questions to: comments@maximumpc.com

always found your articles to be great and interesting. Welcome back, Zak!

–Bruce N. Gaskin

EDITOR, ZAK STOREY, RESPONDS: Thanks for the compliments. I really want to do much more with those builds. We've got big plans, but coronavirus put everything on hold, and the budget cuts haven't helped.

We're looking to change out the cases next issue, and hopefully do more digital content with them, which I hope you'll enjoy. I've forwarded your comments to Gavin; I'm sure he'll appreciate them.

I'm pushing to do more "how it works" features going forward. I've always found dissections and primers really interesting, you'll notice this issue we've got one on mechanical keyboards (which is a bit more niche), but hoping to expand that to GPUs, CPUs, memory, and more over the coming months! Thanks for your continued support—it's very much appreciated in these trying times.

Scientific Limits

I greatly enjoyed reading "The Scientific Method" in the October issue. I am a retired physicist with zero interest in gaming, but a serious interest in numerical computation.

About 10 years ago, I assembled a small Beowulf-type cluster of four PCs, each with an Intel six-core CPU and 24GB of RAM. Aside from the increase in the number of cores, this also increased the total amount of RAM possible with a single motherboard. Has there ever been a *Maximum PC* build featuring a cluster? Could there be in the future? **–Wayne M. Itano**

EDITOR, ZAK STOREY, RESPONDS: The number of comments and emails we've received about that build has taken me aback. I didn't realize how popular a topic it would be, and I'm glad to hear you enjoyed it. We definitely want to expand on it in the future—given the time constraints, we couldn't get all the testing done that we wanted to, so it's definitely something I want to look at again soon.

A cluster build would be amazing. While it's not something I've ever done, I love the idea of it; in fact, I'm pretty sure our publishing house, Future, has a few setups like that, so there's certainly some folks here with the knowledge of how to do it.

Long ago, when I was a humble staff writer, I was pushing to do a ridiculous overkill build for Dream Machine, spurred on by the Asus dual-socket boards. I think the "biggest" board you can get right now is the Asus Dual Scalable Xeon WS C621E SAGE EEB Workstation (what a name); theoretically, you could put two of Intel's 28-core Xeon Platinum 8180s in that, and net yourself 112 threads out of a single system, and 768GB of six-channel DDR4, but the chips alone are $10K each. In fact, I think EKWB does liquid-cooling blocks and components for high-end workstation builds like that. Oh dear, now I'm getting ideas....

I'll be honest with you, though: We need a bigger online footprint for our builds to get parts in now. Our plan is to share some of our build content in a slimline version with Techradar on an interim basis, after the mag goes on sale, to prove to management that the brand warrants getting its website back. Once that happens, we should be able to get parts in far more easily, so Dream Data Machine may become a reality. I certainly want to have a crack at it! When we do that, we can compare value for money and see whether it's worth running a cluster, or a single dual-socket machine instead.

Cohn's Folly

Our approach to the PC is totally wrong. I propose to build a PC inside of a refrigerator. This is no joke. We could double or possibly triple clock speeds while keeping our beer cold! A little levity, but I'm dead serious. Using air or water to cool a heat monster is backward. Our life is a constant battle to dissipate heat and dust from our power-hungry PCs.

No, we start with a modest refrigerator and build a full-fledged PC inside with sealed cut-outs for wires, cables, and so on. Set the fridge at 4 C, and provide extra space for beer and/or wine.

We could probably overclock it by "200% without breaking a sweat." Just give me the credit—call it Cohn's Folly. Now we've "broken" Moore's Law and improved society. The next leap forward in technology is "thinking algorithms or artificial intelligence." **–Alan Cohn**

EDITOR, ZAK STOREY, RESPONDS: I love this idea. And I'd love to implement it. You can bet that if we do, we're 100% calling it Cohn's Folly.

This is actually a really good point. On the whole, no matter how you cool a PC, whether that's with air, or liquid, you're relying on a heat exchanger to reduce temperatures—in fact, I mention it this issue, in our case study on the Mayhems XTR coolant. It doesn't matter if you're running an air tower or a liquid-cooled radiator, you're effectively moving ambient air across a hotter surface to reduce temperature, so there's only so low you can go.

Refrigerated PCs have been done, but there are some considerations to be made, especially with regards to condensation buildup. Everything has to be coated in a special plastic polymer to make sure that the condensation that occurs naturally won't cause a short.

[NOW ONLINE]

USE THE PS4 DUALSHOCK 4 CONTROLLER ON A PC

Knowing how to connect a PS4 controller to a PC is useful whether you're a devoted PC gamer, a PS4 purist, or enjoy both mediums. It's surprisingly easy, as the PlayStation 4 DualShock 4 controller and other PS4 controllers are compatible with most PCs. So, it's worth knowing even if you don't plan to play PlayStation games on your PC. Read the full article here: http://bit.ly/MPCPS4Control

THE BUILDS

BUDGET

ALTHOUGH WE CONSIDERED properly swapping out the motherboard in our AMD Budget build this issue, ASRock's Phantom Gaming 4 remains the most affordable full-ATX scale B550 mobo on the market. Stock availability has seen it come off sale though, so we've made a slight swap over to the AC model, adding Wi-Fi to this machine. We've got a new chip too; high demand for the Ryzen 5 3600 has seen it jump in price, while a sale has made its big brother the 3600X actually come in cheaper. We've left the GPU as is: MSI's RX 5600 XT is still the best-value version of the card.

The AMD build has been peeking at the Intel build's notes, and is following suit with the same GeiL Evo Spear memory kit at a higher 3,000MHz frequency. Inexplicably, this kit is slightly cheaper than the 2,400MHz kit in the Intel system. Both systems now have upgraded SSDs too: Team Group's GX2 model as opposed to the GX1 we were using previously, a newer iteration of the same SATA drive at the same capacity for a mere $2 more.

Although the Core i5-10600K and its ilk are now available, we're holding off on upgrading our CPU in the Intel budget build until they're at least a little bit cheaper. In the meantime, the pricing on our chip-mobo combo here remains steady, with no change at all from last issue. We were left with a slight price discrepancy between our builds here due to several parts from the AMD system climbing in price, so we've decided to spring for a little upgrade.

The upgrade in question? Well, we did contemplate jumping up from a 1660 Super to a 1660 Ti, but the performance improvement is negligible (less than 5fps in most games) for the price jump. Instead, we've opted for a new PSU: The CX450M from Corsair, a semi-modular power supply to help keep our system free from cable clutter. Even with this improvement, our Intel system is the cheaper machine this month. Both are still a lot more expensive than a new Xbox Series S, though... we're saying nothing about that.

AMD INGREDIENTS

PART		PRICE
Case	BitFenix Nova TG	$65
PSU	450W EVGA 450 BR	$55
Mobo	ASRock B550 Phantom Gaming 4 AC NEW	$125
CPU	AMD Ryzen 5 3600X NEW	$215
GPU	MSI Radeon RX 5600 XT 6GB	$270
RAM	16GB (2 x 8GB) GeiL Evo Spear @ 3,000MT/s NEW	$52
SSD	120GB Team Group GX2 2.5" SATA III NEW	$20
HDD	1TB Seagate Constellation ES ST1000NM0001 HDD	$30
OS	Ubuntu Desktop Linux 18.04 LTS 64-bit	$15
Approximate Price:		**$847**

INTEL INGREDIENTS

PART		PRICE
Case	BitFenix Nova TG	$65
PSU	450W Corsair CX450M NEW	$70
Mobo	MSI Pro Z390-A	$130
CPU	Intel Core i5-9600K	$200
GPU	Asus TUF Gaming GeForce GTX 1660 Super 6GB	$230
RAM	16GB (2 x 8GB) GeiL Evo Spear @ 2,400MT/s	$55
SSD	120GB Team Group GX2 2.5" SATA III NEW	$20
HDD	1TB Seagate Constellation ES ST1000NM0001 HDD	$30
OS	Ubuntu Desktop Linux 18.04 LTS 64-bit	$15
Approximate Price:		**$815**

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TAKE IT FROM A GEEK.℠

YOU'LL NOTICE ONE KEY DIFFERENCE in all of our Mid-range and Turbo builds this issue. When it comes to an operating system, you can purchase a single-use OEM key for Windows 10 Home for significantly less than the full OS price from Microsoft. Be careful to buy these from reputable sources, though.

On the hardware side of things, the ASRock Challenger D RX 5700 is no longer heavily discounted, so we've shifted over to MSI's MECH OC model of the same GPU. It's a bit more expensive, but still cheaper than the Challenger D currently. We've managed to save a bit of money elsewhere, swapping our Corsair Force MP600 SSD for Gigabyte's new Aorus Gen4 M.2 drive, which keeps the same outrageous transfer speeds but costs 10 bucks less.

Corsair has been shunted aside in the memory department too, as the Vengeance LPX kit we were using has risen in price. To keep things level, we've changed it out for G.Skill's Sniper X Series 2x8GB kit at the same frequency.

Somehow, the Intel Core i7-10700 is already on sale, and barely any more expensive than our previous 9700 chip. Oh, and you get a free copy of *Marvel Avengers* on PC if you buy one now. Intel Turbo Boost and Comet Lake microarchitecture means that this is a lean, mean, eight-core machine. We've paired it with a new MSI motherboard, the MPG Z490 Gaming Edge WiFi, which only costs five bucks more than the previous MSI Z390 mobo we were using.

We needed a new cooler for this LGA-1200 socket, so we're back with Corsair's reliable dual-fan A500 air cooler, still a quarter off its RRP at $75. Our Western Digital SSD has risen in price as well, so we've made the switch to the T-Force Cardea Zero Z330 to mitigate that somewhat. It's also netted us an extra 12GB of storage over the WD drive, which is a nice little bonus. Both these systems are cheaper than last month, largely due to our switch over to Windows OEM keys.

AMD INGREDIENTS

PART		PRICE
Case	Fractal Design Meshify C	$85
PSU	650W Corsair CX650	$86
Mobo	Asus TUF Gaming X570-Plus	$165
CPU	Ryzen 7 3700X	$300
Cooler	Noctua NH-U12S	$62
GPU	MSI Radeon RX 5700 MECH GP OC 8GB NEW	$350
RAM	16GB (2 x 8GB) G.Skill Sniper X Series @ 3,200MT/s NEW	$60
SSD	500GB Gigabyte Aorus Gen4 SSD NEW	$100
HDD	1TB Seagate Constellation ES ST1000NM0001 HDD	$30
OS	Windows 10 Home 64-bit OEM	$25
Approximate Price:		**$1,263**

INTEL INGREDIENTS

PART		PRICE
Case	Fractal Design Meshify C	$85
PSU	650W Corsair CX650	$86
Mobo	MSI MPG Z490 Gaming Edge WiFi NEW	$200
CPU	Intel Core i7-10700 NEW	$320
Cooler	Corsair A500 NEW	$75
GPU	Gigabyte GeForce RTX 2060 OC 6GB	$320
RAM	16GB (2 x 8GB) G.Skill Ripjaws V Series @ 2,400MT/s	$55
SSD	512GB Team Group T-Force Cardea Zero Z330 M.2 PCIe SSD NEW	$63
HDD	1TB Seagate Constellation ES ST1000NM0001 HDD	$30
OS	Windows 10 Home 64-bit OEM	$25
Approximate Price:		**$1,259**

WE'RE PLEASED TO REPORT that the excellent NZXT H710i is available for just $150 at the time of writing! Granted, it's specifically the black version (not pictured here, more RGB), but it's fundamentally the same case. That shaves $20 off the overall price of both builds here, and we're saving a further $75 thanks to OEM keys for Windows 10 Home. We've been able to make another saving thanks to a good deal on the NZXT C850, a fully modular 80+ Gold PSU for just $120.

In our AMD Turbo build, we've saved $30 thanks to a tidy price drop on the Asus Prime X570-Pro. The announcement of RTX 3000-series cards from Nvidia has triggered some weirdness in 2000-series pricing, and stock availability is still rather limited, but we've managed to find Zotac's three-fan 2080 Super for a reasonable price.

Both coolers have held steady, but our memory has not, and our memory kits have actually dropped a little in price, trimming a few more dollars off our totals. We're using the larger 1TB version of the Aorus Gen4 SSD in the AMD build. The 6TB Seagate drive we have in both machines is also a little cheaper this month, which is good to see.

These delightful savings have unfortunately been somewhat undercut in the Intel build. The Core i9-10900K is no longer benefiting from its tasty post-launch sale; at the time of writing, you can expect to pay upwards of $800 for one. But hey, this is a Turbo build, so the part stays put. We have managed to make some savings elsewhere, with a new motherboard (the MSI MPG Z490 Gaming Carbon WiFi) and a new GPU (Gigabyte's Windforce model of the 2080 Super).

Last issue, our Intel Turbo system was considerably cheaper than its AMD rival. This month, the tables have turned—but it's a much closer race. With the 10900K back up at full price, these two machines have less than 50 bucks between them. Which one would you prefer to own?

AMD INGREDIENTS

PART		PRICE
Case	NZXT H710i	$150
PSU	850W NZXT C850 NEW	$120
Mobo	Asus Prime X570-Pro	$250
CPU	AMD Ryzen 9 3950X	$710
Cooler	Corsair iCUE H115i RGB Pro XT 280mm	$140
GPU	Zotac Gaming GeForce RTX 2080 Super Triple Fan 8GB NEW	$730
RAM	32GB (2 x 16GB) G.Skill TridentZ Neo @ 3600MT/s	$169
SSD	1TB Gigabyte Aorus Gen4 M.2 PCIe SSD NEW	$170
HDD	6TB Seagate BarraCuda ST6000DM003 HDD	$130
OS	Windows 10 Home 64-bit OEM	$25
Approximate Price:		**$2,594**

INTEL INGREDIENTS

PART		PRICE
Case	NZXT H710i	$150
PSU	850W NZXT C850 NEW	$120
Mobo	MSI MPG Z490 Gaming Carbon WiFi NEW	$270
CPU	Intel Core i9-10900K	$825
Cooler	Cooler Master MasterLiquid ML360R ARGB 360mm	$142
GPU	Gigabyte GeForce RTX 2080 Super Windforce OC 8G NEW	$720
RAM	32GB (2 x 16GB) Corsair Vengeance RGB Pro @ 2,666MT/s	$135
SSD	1TB Sabrent Rocket Q M.2 PCIe SSD NEW	$120
HDD	6TB Seagate BarraCuda ST6000DM003 HDD	$130
OS	Windows 10 Home 64-bit OEM	$25
Approximate Price:		**$2,637**

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